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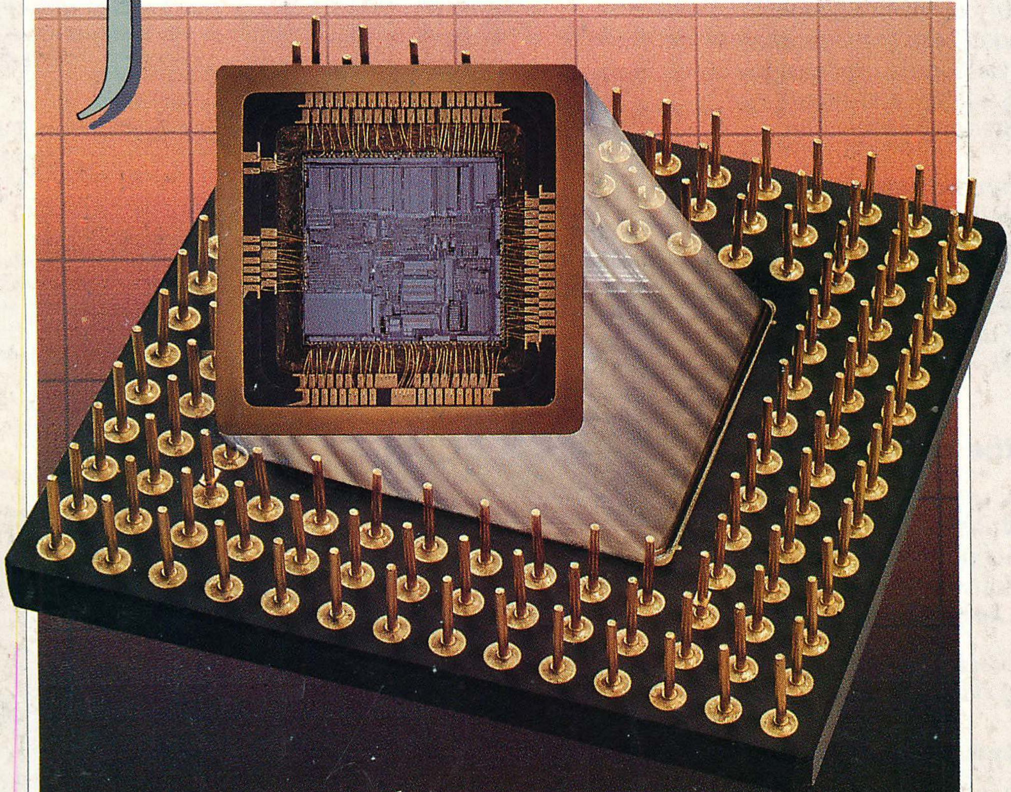

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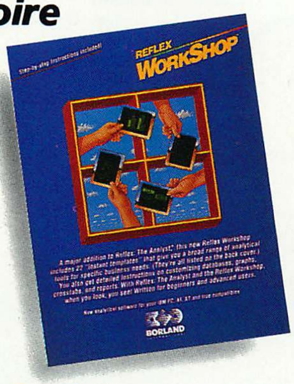

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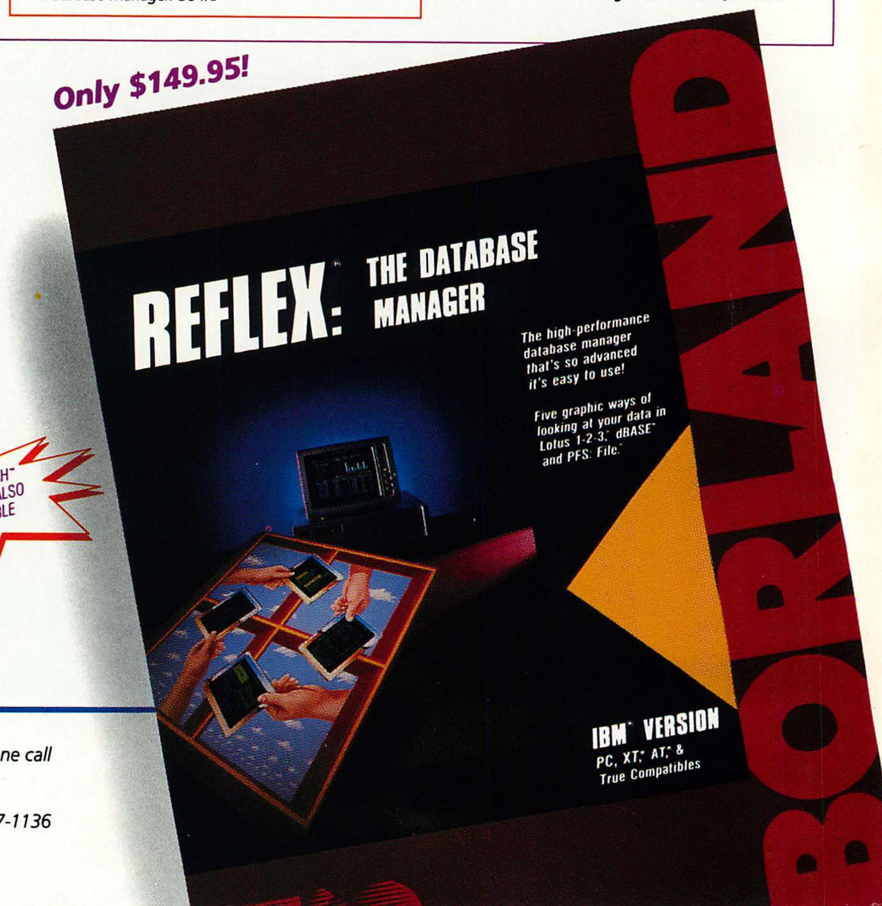

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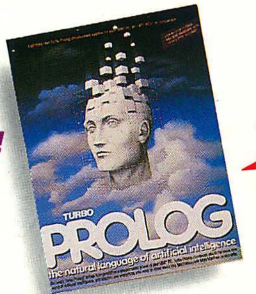

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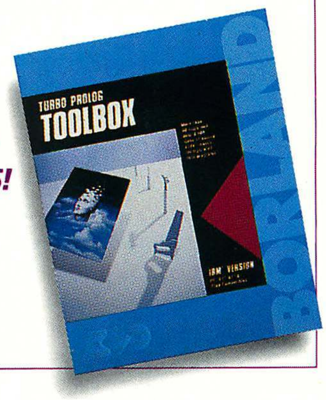

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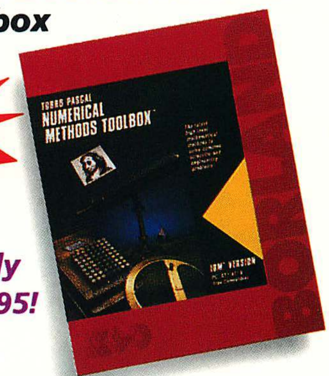

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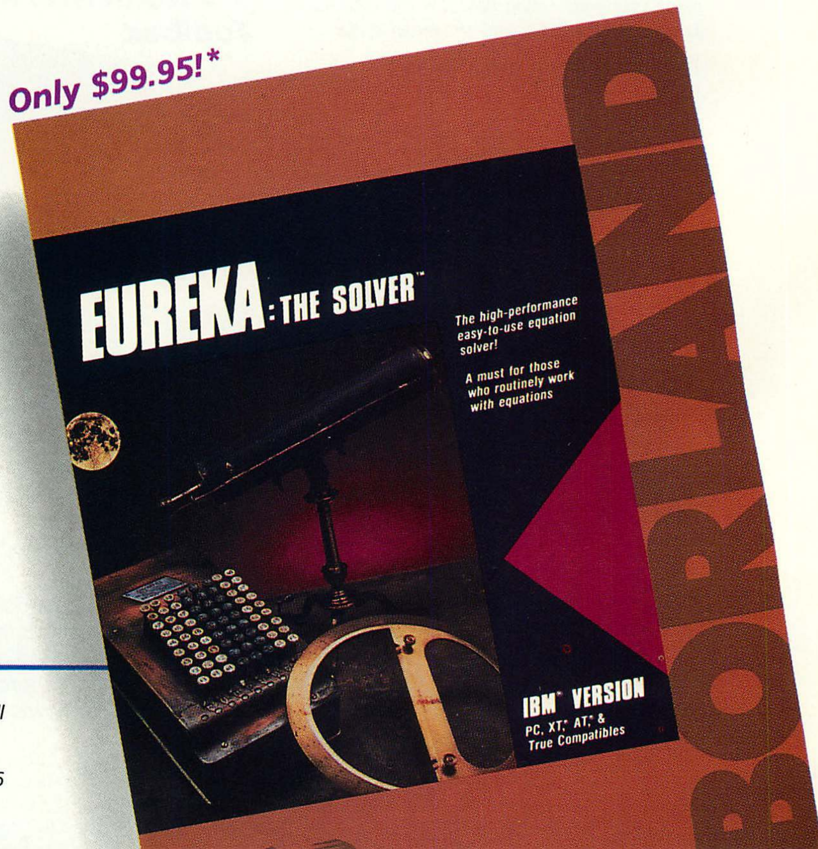

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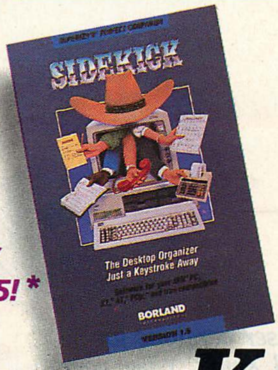

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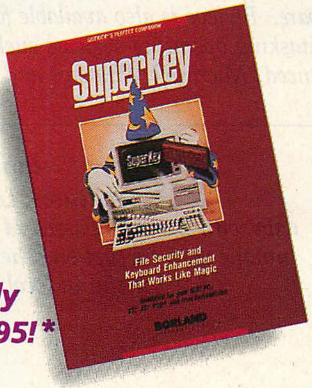

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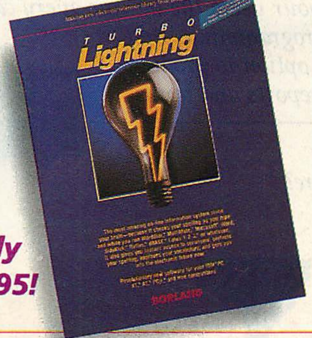

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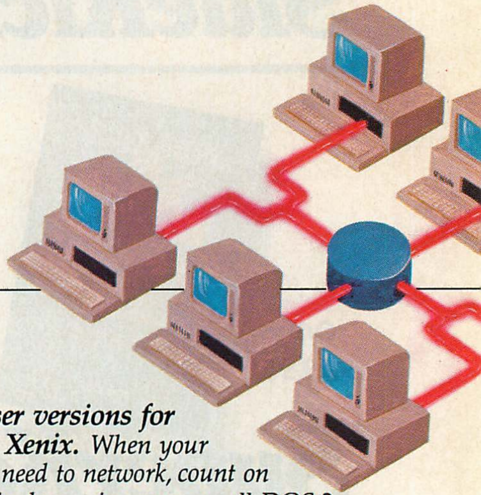

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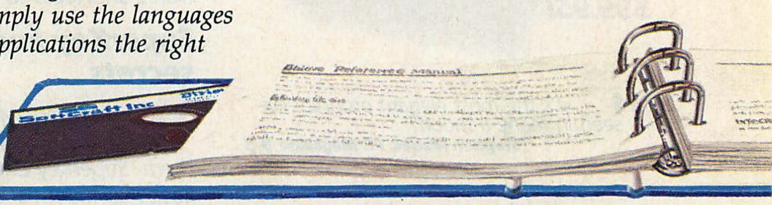

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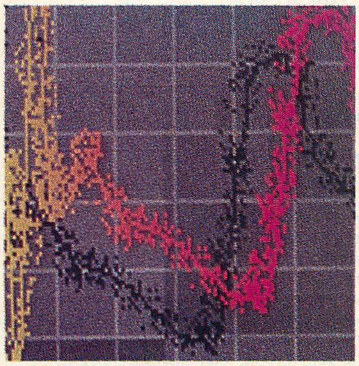

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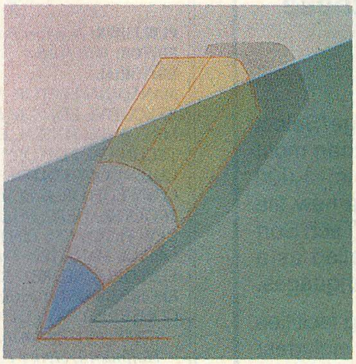

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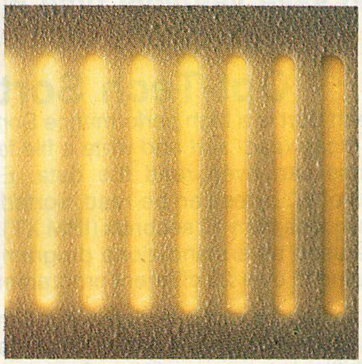

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UPWARD TO THE 80386 / CALDWELL CROSSWY and MIKE PEREZ

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ASYSTANT+ from Macmillan Software converts the IBM PC into a desktop data acquisition and analysis system. In the laboratory or in industry, it can take the place of more expensive, dedicated instruments—albeit at a loss in ultimate performance. 106

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The simplest type of accelerator board runs the PC at a higher clock speed while retaining the 8088, but the performance improvement is far from spectacular. In the first of a series on accelerators, six of these class I boards are reviewed. 126

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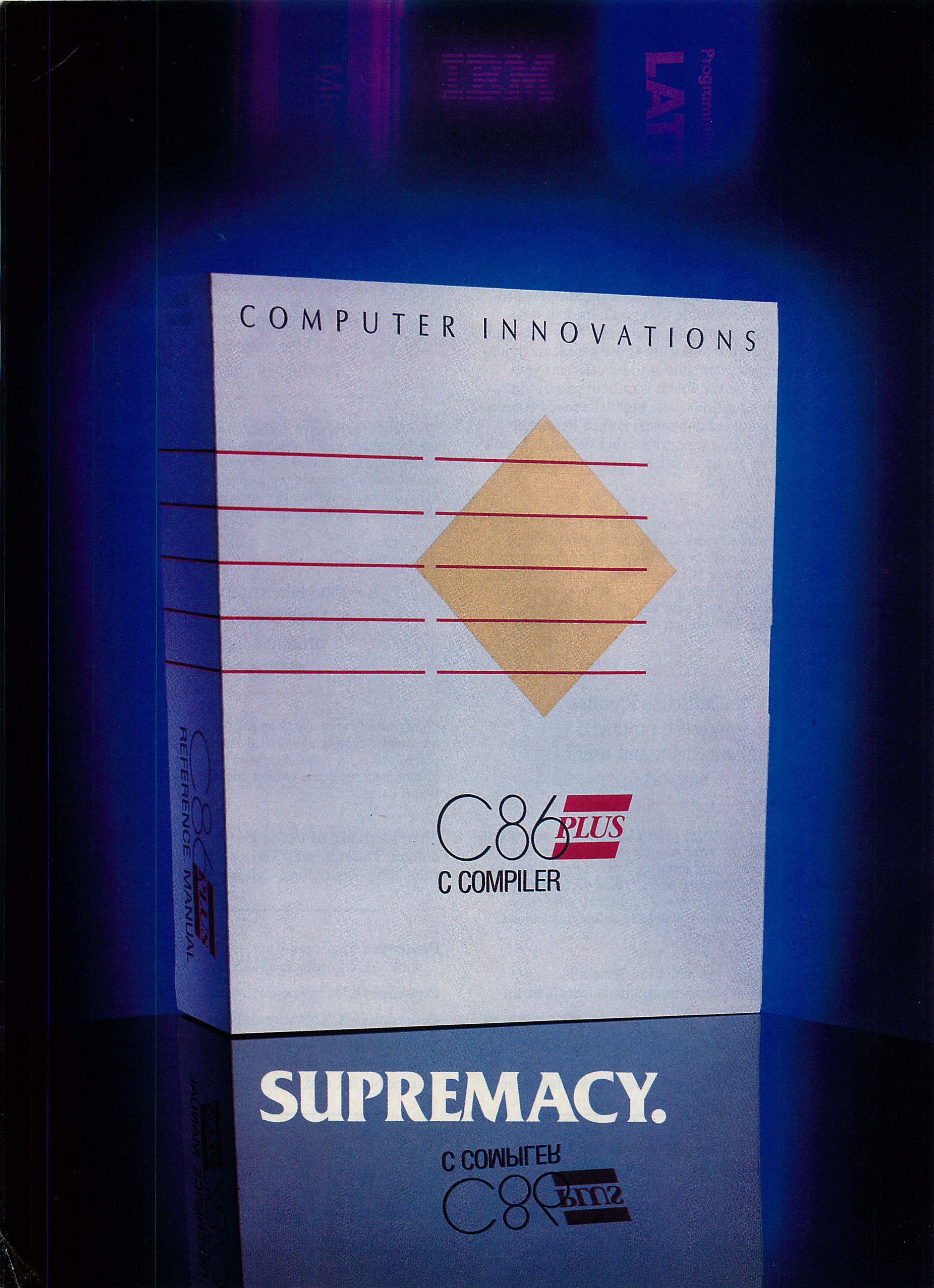
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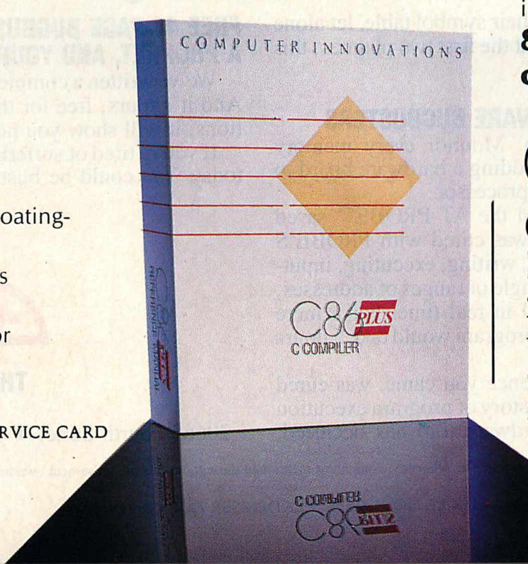

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Second came the plague of not knowing where the program was, or where it had recently been. This compounded the first plague: How could anyone know *what* caused the random memory overwrites? Add to this random interrupts and timing dependencies, and you begin to understand *The Fear* that gripped the city.

Then came the last plague, which brought the wizards to their knees before they even started debugging. Their towering programs consumed so much memory, there wasn't enough room for their symbol table, let alone debugging software. Even if they could get past the first two plagues, this one killed their firstborn software.

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Far Afield with Windows

In which our intrepid editor allows software developers to vent their spleen.

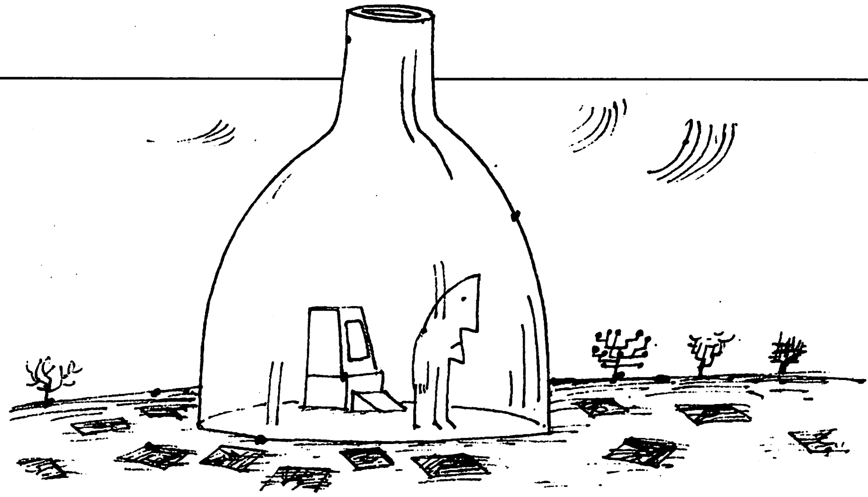

ILLUSTRATION • MACIEK ALBRECHT

It should come as no surprise that *PC Tech Journal* is deeply interested in Microsoft Windows. I should qualify this comment: not everyone on the staff is as interested as I, and there is considerable debate on the subject internally. I suppose no debate would be warranted were the subject uninteresting or, worse, were no other alternatives, such as GEM or DesqView, possible. In fact, the emergence of the 80386 and the probable availability of a protected-mode operating system for the 80286 has motivated a rash of companies to work on operating environments, some of which could prove interesting.

One reason for following Windows is its creator. As far as operating systems and environments go, Microsoft today is the single company of greatest influence. It has the resources to pursue a product until it takes hold in the market and the opportunity to influence the underlying operating system's design to the benefit of the user environment. The company suffers only from technology lagging behind its vision.

Having previously spoken kindly of the product, I may seem two-faced when I say that Windows does not cut the mustard. Although I do believe in the potential of the concept, the current implementation of Windows is unattractive for a variety of reasons, some of which Microsoft can quickly fix and some of which require technology to come to the rescue.

A fixable example is the user interface, which is pretty good for the novice but less than compelling for the expert. It is especially cumbersome for software developers, who for many procedures resort to the more complete DOS command line interface. Microsoft needs to get as many experts and developers as possible interested in the product if it expects a substantial base of software to be written. Improvements to usability, extensions to attract expert users, and a superior software development methodology should be a high priority at Microsoft; I am somewhat concerned that the company is not as aware as it should be of the current state of human factors research.

Another area of difficulty is performance. Windows needs lots of processor and memory. Even with a better, faster processor, like the 80286 or 80386, Windows gets bogged down trying to keep multiple applications available in the DOS 3.x-constrained 640KB of main memory. Here, Windows must be rescued by technology, possibly Microsoft's own. The product needs hardware-supported memory management and better support for multitasking; in short, it needs a new operating system that embodies the concepts present in most minicomputer environments. It will also benefit from the new generation of microprocessor-based graphics cards soon to hit the market.

Even if Windows is improved in these areas, it still must deliver a critical mass of applications to the user community. This may be Windows' greatest failing: few programs have been written to exploit the environment, and those that have are not completely compelling. One other performance problem with Windows may be to blame: it handles *text* very slowly, especially with nonsystem fonts.

What really worries me is that I do not see a rush of developers working on Windows applications. Why?

WINDOWS PAINS

For the last several months, I have conducted an informal and unscientific survey (in other words, I talked to them whenever I could) among developers of products designed to operate in the Windows environment. I have been especially interested in those developers who either already had products for the Apple Macintosh or were developing for both the Mac and Windows. The purpose of the conversations was to determine the degree of difficulty of software development in both environments as a way of better understanding Windows in particular. A second purpose was to determine developer satisfaction with each environment.

Generally speaking, most developers agree that software development in either environment is more difficult than writing a program for execution under DOS, or even a more sophisticated system such as VMS, UNIX, or AOS/VS. The worst part, they also agree, is the learning curve. That first application will take as much as twice as long to develop; subsequent programs benefit from the learning curve but still require additional resources.

Windows gets soundly rapped for that long learning curve. Most developers blame the very poor state of the documentation. One vendor rates Apple documentation for the Mac 9.5 out of 10, while awarding Windows a paltry 3. Detractors claim that Windows' documents are incomplete, full of errors, and badly organized. No complaints were registered about the Mac books.

Developers converting from the Mac find that several important facilities, supplied as part of the Mac environment, are not present in Windows. One example, easily observed by the end user, is Windows' lack of a standard file selection dialog box methodology. This oversight is evident even in Microsoft's own utilities, which use different file selection techniques from program to program; if the feature had been part of Windows, Microsoft's developers would have used it. Other areas mentioned include text editing (having the environment do editing as part of text input), scrollable lists (such as those in the file selection boxes), and drag gray region (moving an object on the screen).

One developer complains that with the Mac, the hardware is a known quantity while with Windows, it is unknown. Of course, hardware independence is supposed to be a strength of Windows; this developer clearly longed to exploit the hardware and is frustrated by the lack of direct control within Windows. It is also clear that the information Windows can provide to the application about the attached hardware is probably too limited for most developers' tastes.

Hardware independence provokes another complaint. Although Windows is touted as WYSIWYG (what you see is what you get), the developer has to work quite hard to make this happen. Mac developers claim to have it by default; Windows developers say that what you see on the screen may not come out that way on the printer until the application is properly tuned, and finding the tuning knobs apparently is not easy. Again, this seems to be a case of captive hardware on the Mac versus the open hardware of the PC.

Curiously, only one developer touted the advantage of hardware independence from a time and resource point of view. A strength of Windows should be that it prevents the software developer from having to develop drivers to cope with the hundreds of possible display and hard-copy options. However, most developers do not report any time savings to date. This may be due to the number of drivers currently available and the fact that the design specification for the driver interface has not stabilized.

Finally, there is almost universal objection to the style and quality of Microsoft technical support, and equally universal praise for Apple. The major problem seems to be that Microsoft is slow to turn around the answers and, because it isolates the development staff, often loses information as the problem is first translated to the Microsoft development team and back again to the questioner. According to Mac developers, The Macintosh support program allows direct contact with Apple's internal development staff and thereby generates quick, accurate information.

I asked Microsoft to respond to some of these support criticisms. A spokesman pointed out the company's primary sources of support. The first, the Microsoft Windows Development Seminar, is presented periodically around the country. The price varies from $450-650, depending on location, and includes a copy of the Windows Development Tool Kit. Microsoft also offers two 5-day courses at its headquarters in Redmond, Washington: an introductory course for $450 and an advanced course for $550.

Another source is DIAL, an on-line support service. *PC Tech Journal* has not had an opportunity to evaluate the service since it was restructured; formerly, we considered it far too expensive. DIAL is apparently under revision again, and we do not yet know its final form or cost. I am surprised that on-line, passive service is not free, to encourage the development of the applications Windows desperately needs.

A common theme rings through all these objections. An environment such as Windows is desirable because of its philosophical foundations, such as hardware independence, its virtual graphics interface, and its user interface. Support for Windows is growing, albeit more slowly than Microsoft might like. From the complaints noted here, that growth is anything but painless.

ERRATUM

My December editorial ("The RT Mystery") contained two errors. At the top of the second column on page 12, the numbers 240 and 224 should have been 2^{40} and 2^{24}. We regret the error.

UNDERSTANDING PERFORMANCE

This month's issue of *PC Tech Journal* has a lot to do with performance. Our cover story, an overview of the architecture of the Intel 80386 processor (p. 50), leads into what will become ongoing coverage of the newest desktop performance champ; we will follow next month with a comprehensive review of the Compaq Deskpro 386. At the same time, this issue includes the first of several articles examining accelerator products for PCs and ATs (p. 126).

The market is flooded with such products, from faster clocks to add-in 80386 boards, that improve the performance of the PC. These products are often attractive because the next performance increment, in the form of a complete system, can be very expensive. Building a better machine in stages can mitigate these costs.

The process of choosing from the long list of possibilities is much more difficult than adding memory or serial ports, and much more frightening. Accelerator products do not just extend the existing system, they fundamentally alter it. How the "new" system will work is something that the careful analyst must understand well in advance. The tendency is to think purely in terms of raw CPU power, but other factors influence performance as well. Graphics performance, I/O (bus) bandwidth, disk speed, and floating-point operation can each profoundly affect the bottom-line performance of the application. Worse, combinations of these factors are the more usual case, making the task of optimizing a system configuration for a particular task very difficult if the machine is put to general-purpose work.

PC Tech Journal is presenting the examination of accelerator products because we believe they offer viable opportunities for the millions of 8088-based computers. Our conclusions about the products are conservative; as is our custom, we are providing as much information as we can, but we rely on the common sense of our readership when it comes to making product decisions. We urge you to analyze your environment carefully and then choose and recommend the options that most closely address your and your client's requirements.

—WF

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*The benchmark procedure was adapted from "Benchmarking Database Systems: A Systematic Approach" by Bitton, DeWitt and Turbyfill, December 1983.

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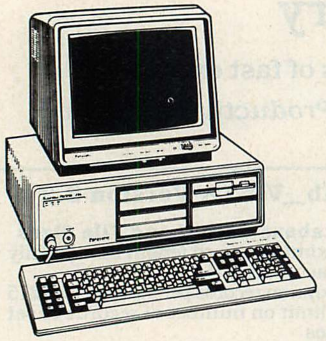

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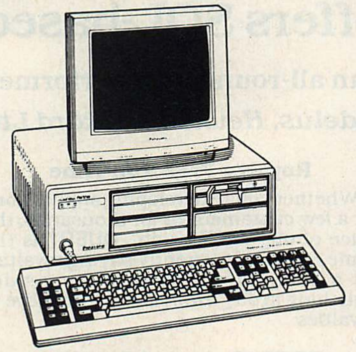

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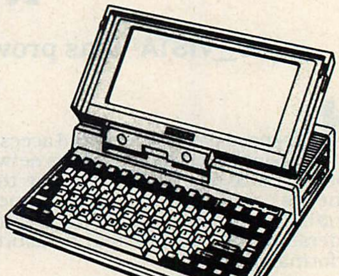

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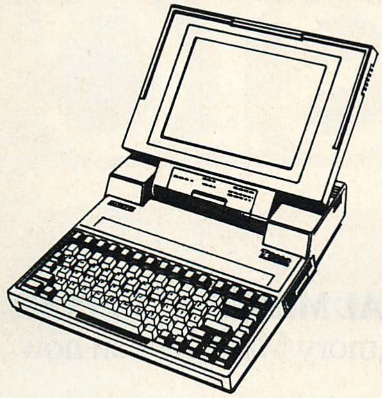

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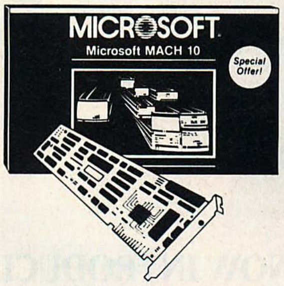

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Better BASIC

NOW INTRODUCING VIRTUAL MEMORY SUPPORT

BetterBASIC with the optional Virtual Memory Manager can now address 400,000,000,000 bytes of memory!

BetterBASIC Application Development System **$199.00**

The BetterBASIC Application Development System provides very close compatibility with PC-BASICA and GW-BASIC, yet provides numerous new and sophisticated language features such as: program Block Structures, recursive Procedures and Functions with local variables, structures, Records and Pointers and last but not least support of large memory.

Virtual Memory Manager **$99.00**

The Virtual Memory Manager expands Better-BASIC's data space into the giga-byte range and finally breaks the 640k byte barrier for array sizes. Not only can you directly address all expanded memory supported by LIM/EMS memory boards, you can also address any RAM Disk, Hard Disk or even a Floppy Disk as if they were ordinary RAM.

Virtual Memory Manager-Network Version **$250.00**

This version of the Virtual Memory Manager allows Virtual Memory to be distributed throughout a Local Area Network. It also provides File, Records and Field Locking to control access to shared data.

C-Link **$99.00**

This software package allows BetterBASIC to access C-language library functions from within BetterBASIC. Currently supported are Lattice and Microsoft C.

Screen Design System **$199.00**

This package truly takes the drudgery out of creating display screens and data entry screens. An interactive Screen Editor lets you "paint" your display screens exactly as you want them to appear in your program. The completed screens take the form of disk resident images. A run time library module provides many new BetterBASIC procedures and functions for interacting with the display screens to simplify the use of pop-up menus and data entry screens.

Btrieve™ Interface **$99.00**

This is a high level BetterBASIC interface to the ever popular Btrieve™ file manager from Soft-Craft. Instead of Assembly language calls this module provides high level BetterBASIC program access to all Btrieve™ functions. Use it to design your own database application in BetterBASIC.

8087/80287 Math Module **$99.00**

This module allows you to use the 8087 or 80287 co-processor to significantly accelerate programs which are floating point calculation intensive.

Decimal Math Module **$99.00**

If you are a business programmer, you are probably frustrated by the many roundoff problems caused by ordinary IEEE format floating point numerical operations. The BetterBASIC Decimal Math Module which offers variable precision from 6 to 24 digits, drastically reduces roundoff problems in business applications.

BetterTools™ **$99.00**

This is a collection of more than 150 useful extensions to BetterBASIC such as time and date computations, encryption and decryption, low level file directory access, hyperbolic function and much more. No BetterBASIC programmer should be without BetterTools™.

CIRCLE NO. 195 ON READER SERVICE CARD

SPECIFICATIONS

BetterBASIC is GW-BASIC and PC-BASICA compatible; runs on IBM PC and compatibles.

HARDWARE REQUIREMENTS

CPU: IBM PC, IBM PC XT AT, COMPAQ, IBM PC Compatibles
Memory: 256KB min up to 640KB
Display: Monochrome or Color
Disk Drive: One 5¼″ floppy, single or double sided
Operating Systems: MS-DOS 2.0, 2.1, 3.0, 3.1

DATA TYPES:

Numeric Data:
- BYTE, range: 0 to +255
- INTEGER, range: − 32768 to + 32767
- REAL, range: Single Precision 8.43×10^{-37} to 3.37×10^{38}
  Double precision 4.19×10^{-307} to 1.67×10^{308}
- Binary Math, Single/Double/Mixed Precision
- Mixed mode numeric expressions will always be REAL.

String data:
- Variable from 0 to 32767 characters in size.

Record Variables:
- Allows grouping of dissimilar data types into a single logical variable. Elements of a RECORD are addressed as FIELDS and can be of any type, including ARRAY, RECORD and POINTER.

Array Variables:
- N-dimensional arrays of any type, including ARRAY, RECORD and POINTER. Dynamic arrays like PC-BASICA

Pointer Variables:
- Allows indirect reference to any data type. Can be used with RECORD variable to create linked lists, or to create relational data structures.

In addition supports PC-BASICA record types.

BetterBASIC BENCHMARK COMPARISON
in milliseconds

	Better BASIC			IBM INTERPRETIVE		IBM COMPILED	
	SP*	DP*	8087 DP	SP	DP	SP	DP
REAL FOR/NEXT	1.3	1.4	0.55	0.93	0.93	0.7	0.7
ASSIGNMENT	1.0	1.0	0.93	1.5	1.5	0.1	0.1
ADD	0.77	1.1	0.44	1.6	2.3	0.4	0.4
MULTIPLY	0.88	1.8	0.49	1.9	3.0	0.5	0.8
DIVISION	1.0	3.0	0.49	2.8	19.7	0.6	1.1
LOGARITHM	5.7	15.6	0.55	7.5	64.0	4.0	11.9
EXPONENTIAL	7.4	27.0	0.66	6.5	43.0	3.6	10.8
SINE	4.7	17.0	0.82	17.6	35.0	3.2	12.4
COSINE	4.5	17.0	0.77	25.0	41.0	3.5	12.7
TANGENT	7.2	18.0	0.66	44.0	94.0	6.9	26.0
X^Y	13.8	44.5	1.1	15.2	115.0	7.7	24.0
SQR (SQUARE ROOT)	1.4	6.5	0.33	7.2	95.0	1.1	3.5

*SP = Single Precision
DP = Double Precision

ADDITIONAL BetterBASIC STATEMENTS

ANY ARG
APPEND
ASH
ASSIGN
AUTODEF
BIN$
BREAK
BREAK OFF
BYE
BYT
BYTE
BYTE ARG
BYTE ARRAY
BYTE ARRAY ARG
BYTE ARRAY PTR
BYTE ARRAY STRUC
BYTE PTR
CHANGE
CHAR$
CHECK
CLD
CLW
CODE
COLOR BORDER
COMMAND$
COMPRESS
CONSTANT
DEFINE WINDOW
DEL$
DIR$
DISABLE
DO
DO IF
DO UNTIL
DO X TIMES
DRIVE$
DYNAMIC
END DO
END FUNCTION
END PROCEDURE
ENDPROC
ERRORMODE
EXIT
EXIT GOSUB
EXIT X LEVELS
EXTERNAL
FRAME
FRAME WINDOW
FREEDISK
GOTO END
HEADER
INPUT FROM
INS$
INTEGER
INTEGER ARG
INTEGER ARRAY
INTEGER ARRAY ARG
INTEGER ARRAY PTR
INTEGER ARRAY STRUC
INTEGER FUNCTION
INTEGER PTR
INTERRUPT
INTERRUPT CLEAR
INTERRUPT ON/OFF
INTERRUPT PROC
INTERRUPT RESTORE
INTERRUPT SAVE
INTR
KEY=
KEYWORD ARG
KEYWORD SET
LIST ALL
MAIN
MAKE MODULE
MAKE PROGRAM
MAX
MAX$
MEM
MIN
MIN$
MODULES=
OFFSET
ON INTERRUPT
PRECISION=
PRINT TO
PRINT TO USING
PROCEDURE
PROCS=
PUBLIC
READ RECORD
READCHR
READCHR FROM
READLINE
READLINE FROM
READ RECORD
REAL
REAL ARG
REAL ARRAY
REAL ARRAY ARG
REAL ARRAY STRUC
REAL FUNCTION
REAL PTR
RENAME
REPEAT
RESTART
RESTORE PAR
RESTORE SCREEN
RESULT=
RETRY
ROT
SAVE MODULE
SAVE PAR
SAVE SCREEN
SCOPE=
SCRATCH
SEG
SELECT
SET
SET CURSOR
SH
SHELL
SIZE
SIZE$=
SPAN
STACK=
STATUS=
STATUSLINE
STRING
STRING ARG
STRING ARRAY
STRING ARRAY ARG
STRING ARRAY PTR
STRING ARRAY STRUC
STRING FUNCTION
STRING PTR
STRUCTURE
SYSCALL
SYSCODE
SYSFLAGS
TYPE
UPPER$
WHILE...DO
WINDOW
WOR
WRITE RECORD
WRITE TO
XMEM
XMEM=
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CUSTOMIZES BRIEF FOR dBASE III

Since its introduction, BRIEF has been sweeping programmers off their feet. Why? Because BRIEF has *every* feature they need. Now, with the introduction of dBRIEF, you can take advantage of BRIEF customized to become a complete integrated environment for development with dBASE III and III Plus, CLIPPER or dB/III Compiler

MORE EFFICIENT DEVELOPMENT

Increase Your Productivity

Developing an application in dBASE can be quite a tedious process considering all that dBASE can't do. To compensate, some programmers use several utility programs that have to run separately, and then integrate the results into one application. This slows you down — you spend more time watching your computer than you do programming.

dBRIEF gives you a central core — a single work area with common commands and operational consistency.

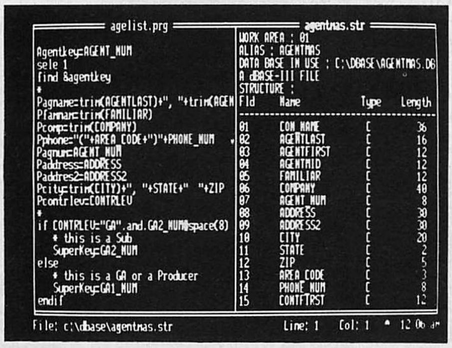
Reviewers at BYTE, INFOWORLD, DATA BASED ADVISOR, and DR DOBBS JOURNAL all came to the same conclusion — BRIEF IS BEST. And now it has been customized for dBASE programmers with dBRIEF.

System Requirements
dBRIEF requires BRIEF, version 1.32 or later, and IBM or IBM compatible hardware with hard disk media. At least 384k RAM, 512k RAM is recommended if you want to operate dBASE within dBRIEF, and 640k RAM is preferred. Floppy systems are not recommended.

A SINGLE PRODUCTIVE ENVIRONMENT

Save time and reduce mundane work using dBRIEF. Without ever leaving the dBRIEF core you can:

- Generate dBASE code for interactive data entry by drawing the screen with BRIEF.
- Use the special "speed coding" libraries to write your programs with the absolute minimum number of keystrokes.
- Optimize your dBASE code.
- Compile a program (using Clipper or the dB/III Compiler) with 1 keystroke.
- Indent code automatically.
- View several files simultaneously.
- Automate line and column input for SAY and GET.
- Run DOS programs like dFORMAT and dCONVERT.
- Easily enter graphics characters.
- Select colors or video attributes for your screen.
- Customize dBRIEF to your needs.
- Modify the dBRIEF source code.



View your file structure while you program.

PROGRAM EDITING YOUR WAY

A typical program editor requires you to adjust your style of programming to its particular requirements — NOT SO WITH BRIEF. You can easily customize BRIEF to your way of doing things, making it work naturally, intuitively. BRIEF can be used for *any* programming language. Even without dBRIEF it provides:

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- Uses all available memory
- Keystroke Macros
- Reconfigure keyboard
- Windows
- Regular expression search
- Horizontal scrolling
- Comprehensive Error Recovery
- Programmable Macro Language
- EGA and Large Display Support
- Compile within BRIEF
- Adjustable line length – up to 512

"[dBRIEF] acts as the central command post for writing and editing dBASE programs with BRIEF, but it does much, much more to increase your productivity."

— PC Magazine, July 1986

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CIRCLE NO. 130 ON READER SERVICE CARD

MOVING AMONG 286s

I enjoyed Steven Armbrust and Ted Forgeron's review of the Compaq Deskpro 286 ("Out from the Shadow of IBM: Compaq Deskpro 286," August 1986, p. 80). Considering the short time they had to work with it, their assessment was reasonably complete. However, a few other items should be mentioned.

For the past seven months, I have been using a Compaq Deskpro 286 at home and an IBM PC/AT at work to do Pascal program development. A short time ago, we purchased a Compaq Portable II at work, and, in many respects, I like it the best of the three.

In January, I purchased a Deskpro 286 Model 1 with the intention of adding my own hard disk. Overall, I found the dealer (Computerland) was not knowledgeable enough to answer even the simplest technical questions. However, after about two months, the store did manage to supply the technical reference manual that was ordered at the time of the original purchase. On the other hand, the Compaq customer service people were very helpful when I was trying to find the jumper settings for a memory upgrade to 2.1MB. Incidentally, the memory board must use all 64K- or 256K-bit chips.

Something that the authors completely missed is that most Compaq disk types do not correspond to IBM disk types. I found this out the hard way. I installed an IBM type 8 in my Compaq and found that the heads were hitting the stops. The solution was to define it as a Compaq type 6 and give up the use of 1.5MB of disk space. So far, I have not been able to find out how to set up for a non-Compaq disk type.

On the matter of keyboards, I like the Compaq keyboard better possibly because I pound the keys fairly hard and the IBM gives me the feeling that it will fall apart any minute. The spacing between the function keys and the main keys is smaller on the Compaq and this causes some problems when using function key overlays (such as the one used with WordPerfect). The Portable II function key location causes me some problems when I go back and forth between computers. Going back and forth between the old and new AT keyboards is much worse than going between the two Compaq keyboards, however.

I am using an STB EGA+ card in my home Deskpro. The Portable II at work was purchased to do field software maintenance on a product that uses an EGA-equipped AT. For this reason, it would be desirable to have an EGA card in the II. However, I have not been able to use the internal monitor on the II with an EGA card installed. It appears that if I wanted to drive an EGA monitor at some field location, I would have to open the II up and take out the Compaq card and install the EGA card. On the IBM it is possible to have a monochrome and color card installed in the cage and switch back and forth. The problem with the Compaq II appears to be that it uses a color card to drive the internal monochrome display. Therefore, installation of a second color card causes problems.

I have been told that a bug in the AT keyboard BIOS will cause an occasional system hang or crash when the system reset is done on the return from extended memory access. Experiences that people at work have had with their HP Vectras make me suspect that in respect to the keyboard BIOS, HP has done an exceptionally faithful job of cloning the IBM BIOS. I wonder, did Compaq avoid this problem?

On other matters in the article, the Torx screws are a pain when you do not have the drivers. I am not sure what I'll do when I need to replace lost Torx screws—probably replace them all with allen-headed screws. The interference on slot 1 caused by the brace is unfortunate because that is a 16-bit bus slot. The STB EGA+ is supposed to be mounted in slot 1 only, but it seems to work in slot 2. Backplate clearance around slot 1 is a bit tight and makes it impossible to plug in the monitor cable connector into a card mounted in slot 1. The Compaq technical reference manual does not contain the BIOS list like the AT manual does, but overall I find it more useful for BIOS function applications than the IBM manual. In the final analysis, I am glad I chose the Compaq Deskpro 286.

David L. Spooner
Wilmington, DE

Unfortunately, the Compaq Deskpro 286 supports only 15 hard-disk drive types and does not have a type that corresponds to IBM hard-disk type 8. IBM type 8 has 733 cylinders and 5 heads for a total of 31.9MB. As you mentioned, the closest fit that the Deskpro 286 has is type 6 with 697 cylinders and 5 heads for a total of 30.3MB. The good news is that the Deskpro 386 has 32 additional drive types, for a total of 47. Type 20 matches the characteristics of your add-in hard disk exactly.

As for enhanced graphics in the Portable II, Compaq is one step ahead of your request. According to the company, its new Enhanced Color Graphics Board (ECGB) will work equally well in the Portable II as it does in the Deskpro 386. You can remove the Portable II's old dual-mode display adapter, install the ECGB, and plug the internal display cable directly into the special (but undocumented) connector on the ECGB. This board will even drive the internal dual-mode display while in EGA modes, or you can connect an external enhanced color display.

—Steven Armbrust and Ted Forgeron

PRO TURBO

I was delighted to see *PC Tech Journal* provide a closer look at Prolog development tools in the November 1986 issue ("Prolog Arrives," Michael Covington

and Andre Vellino, p. 52), but your reviewers have misunderstood the real advantages that Turbo Prolog brings to AI development. Instead, they focused on the deviation from Clocksin and Mellish's *Programming in Prolog*. Turbo Prolog is not a C&M Prolog, but then Turbo Pascal is not a Wirth Pascal; nor was it ever intended to be. The reviewers have not looked closely enough at Turbo Prolog. Obviously, they ran their usual routines and disliked the fact that they had to modify them.

There is a good reason why Prolog has not yielded commercial applications in the more than 10 years it has been around. Its first implementations were developed in universities for universities, a situation in which ease of programming comes first and programs typically are not run more than once. In this environment, it often is enough to know that the program can work.

The world of commercial application development is much more demanding. In fact, the most important criteria is speed and compactness of executable programs: specifically as it pertains to development on microcomputers. Your review points out the capability of Turbo Prolog to generate programs that run many times faster than any other Prolog; and the benchmarks in your article allude to this fact even though the authors make no mention of it in their review. These benchmarks show that Turbo Prolog runs from 2 to 40 times faster than the other compilers compared. In many cases Turbo Prolog was too fast to measure accurately.

Many people have considered asserting rules at runtime to be a very important capability. In Turbo Prolog, this can be done with the database. While the assertion of new rules yields one important advantage—making it easier to build a Prolog or rule interpreter inside Prolog—the question arises as to why anyone would want to do that. The reason for building a customized Prolog interpreter in Prolog is grounded in the fact that the standard Prolog interpreter is not good enough to support many applications. The programmer wants to do unorthodox things, such as firing the rules from the right to the left, or connecting a certainty factor to the rules, or have some explanation as to why a particular solution is reached. In these cases, Turbo Prolog is clearly the superior language implementation.

While existing Prolog interpreters are very flexible, they are still restricted to a single inference mechanism because they are too slow and require too much memory to be included in a customized inference mechanism for an application. Turbo Prolog provides the speed and small code size that allows a programmer to write a rule interpreter or inference mechanism that will be truly useful in real applications, while requiring very little extra effort.

Furthermore, anyone who has done any significant programming in Prolog knows that one of the big drawbacks of Prolog has been the difficulty of debugging programs. Turbo Prolog's type system, when combined with its trace capabilities, solves that problem. In addition, it is widely accepted that the disadvantages in having to declare types are more than compensated for by the fact that it's much easier to correct a mistake identified by the compiler than to locate it as a runtime error. This situation is especially true in Prolog because, by construction, Prolog fails when the types do not match. Here again, this is important if one wants to write real programs in Prolog.

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*as reported in Micro Cornucopia, August-September 1985. Turbo Pascal is a registered trademark of Borland International.

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With regard to mixed types, while it may be tedious to write

[int(1),int(2),symbol(go)];

this is only a very small part of the whole picture. Lists are usually created dynamically instead of being typed in by hand, and then Turbo Prolog's implementation has no disadvantage. On the contrary, Turbo Prolog makes it easier to handle objects when you can use the functors to classify objects instead of using type predicates such as **is_atom** or **is_integer**. This is truly an advantage for the serious programmer.

What you get with Turbo Prolog is a complete development environment with a user interface that your reviewers have qualified as "the best ever developed." It is a fast compiler, and an implementation of Prolog that allows for easy debugging. It has fast and small executable code, as well as low-level access to the machine. In essence, Turbo Prolog is the best tool available for building serious AI programs, and it is particularly well suited for development of expert systems.

Philippe Kahn, president
Borland International, Inc.

We did not say that Turbo Prolog was not a good product, only that it was not Turbo Pascal. For users who want to sacrifice some versatility in exchange for a gain in speed, it works well.

The changes from Wirth Pascal to Turbo Pascal were almost additions, not deletions, of features. Only the problematic _get_ statement was deleted, and Wirth did the same thing himself in Modula-2. Turbo Prolog, on the other hand, differs from Edinburgh Prolog largely by the deletion of features and the addition of restrictions.

The type system of Turbo Prolog would be welcome as an optional add-on to facilitate debugging. In its present compulsory form, however, it makes some basic algorithms, such as generic list operations, impossible to express.

—Michael A. Covington

BASIC UNLIMITED

I just finished reading the review of the BASIC Development System (BDS) by BetaTool Systems (Product Watch, Paul Hultquist, June 1986, p. 196). As a devoted user of this product I was dismayed by the reviewer's lack of appreciation for its valuable features. Too much time was spent discussing things such as how to copy and load the program rather than its advantages for power users. Just a few examples:

Imagine running a BASIC program that crashes with the message "Illegal function call in line 1230" and then wondering "how did I get there?"

With BDS, it is necessary only to type T<Enter> and the system will respond by printing out the last 12 lines that were executed.

Then to find what caused the illegal function call, all you have to do is type V"1230<Enter> and BDS will display the current values of all the variables used in that line.

But you know what is displayed shouldn't be the value of LIMIT. To find another place where and how you used it, type X;LIMIT<Enter> and back comes a listing of every line that contains the variable LIMIT.

Now you look at line 2450 and wonder in what context LIMIT is used at that point. Type L2450<Enter> to establish line 2450 as the current line and then type ,<Enter> and the screen will fill with a listing of a portion of your program with line 2450 right in the middle of the screen.

Now you decide to renumber your program but you are leery because you know that when BASIC renumbers a program you are apt to get the message "Undefined line 1500 in 3200." But by then it is too late because BASIC has already renumbered the program and the line containing the undefined reference is no longer line 3200 and you cannot find out what place in the program used to contain the line numbers around line 1500. Therefore, you type RU<Enter> and BDS scans the program for undefined lines and reports them, but it does not make any changes in the program.

These are just a few of the features that BDS adds to standard BASIC.

One of the other features that makes BDS such a pleasant tool to work with is the ability to customize your copy of BDS so that it works the way you want it to work. If you want your Find Facility to be case insensitive (the default is case sensitive), it can be configured the way you want. If you want Dump to bypass null or zero elements, so be it. You can have your printer initialize to WIDTH "LPT1:", 132 every time you invoke BASIC, or you can set the default BASIC function keys to your own values.

I have talked to other users of this fine product and all of them agree that once you have used it, it is almost impossible to do any work without it. Add this to the fact that BetaTool Systems provides courteous and accurate sup-

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port over the telephone and you have what I consider to be the most useful tool in my programming arsenal.

Al Weiss
San Diego, CA

AN EARLY VINTAGE

I would like to offer a comment regarding Michael Covington's very useful article on converting the IBM Color Graphics Adapter (CGA) to improve reproduction of color signals on composite monochrome monitors ("A Better CGA," July 1986, p. 137). Because of the values of the resistors pictured, I assume the board photograph that opens the article is of an earlier CGA. My adapter is early 1983 vintage, yet it is different from the one shown, as well as the version described later in the article. There appear to be at least two "early" versions, which could prove confusing to those who attempt to modify their CGA if it is like mine.

My board has a group of 100-ohm (Ω) isolation resistors in the RGB lines. Physically they are located between the 9-pin connector and the U67. This area is outlined in white at the left of the top photo on page 137 of your article. These resistors are not on the schematic in my edition of the *Technical Reference Manual* (1502234). Resistor R8 is in roughly the position of the 15KΩ resistor shown at the center in the photo. The blue-bodied resistors shown at the right are R5, R6, and R7 (from top to bottom). There are no pads for the resistors to be added.

To modify a unit laid out as above, one end of each added resistor is soldered (carefully) to righthand pads for the 100-Ω resistors, starting with the one nearest the RGB connector. These signals are for red, green, and blue respectively, proceeding toward U67. The other end of the 15KΩ resistor can use the pad formerly occupied by R8 where it joins R5 to R7. The remaining ends of the 10KΩ and 12KΩ resistors are then soldered to pads R6 and R7. The modification produces a vast improvement in the performance of the adapter.

Stuart E. Bonney
Richardson, TX

It does appear likely that IBM made more versions of the circuit than it documented. Thank you for the information. The 100-Ω resistors apparently provide some degree of protection against short circuits or incorrect connections to the output connector.

—Michael A. Covington

FACE TO FACE

I have been a subscriber to *PC Tech Journal* for several years and have enjoyed the contents, both editorial and advertising. It was with a great deal of dismay that I read your Product of the Month column for November 1986 ("A Basic Improvement," Will Fastie, p. 31) and saw an example of one of the worst practices in magazine publishing.

Working in technical publishing, I realize the pressures that batter the editorial staff from all sides—advertisers as well as readers. I realize also that space salespersons frequently do not feel bound by standards of journalistic integrity. However, selling an advertisement to Microsoft for its QuickBASIC 2.0 on page 30, just across the gutter from your glowing review of the very same product on page 31, impugns the integrity of your magazine, its editors, production people, and advertising staff.

I truly hope that the advertising was not deliberately sold against the editorial on the next page. I would hate to think that a magazine with the reputation of *PC Tech Journal* would prostitute itself to an advertiser.

I understand well that the editor of the magazine is frequently helpless to block the whims of the sales staff. How-

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News about the Microsoft Language Family

The Evolution of Optimization Techniques Used in Microsoft® C.

One of the reasons the Microsoft C Compiler has been chosen by leading software developers is because of the optimization techniques used in the code generator of our production-quality compilers. Microsoft's advanced optimization capabilities mean that generated code is small and fast.

Local optimization was implemented in Microsoft C Version 3.0. Most MS-DOS®-based C compilers implement this technique, but good local code generation such as that in Microsoft C Version 3.0 uses *pattern matching* to select optimal sequences and *register targeting* to evaluate expressions in their target destinations. *Peephole analysis* is also used and includes such optimizations as *redundant load/store* analysis. This increases the efficiency of the resulting code by removing unnecessary or duplicate instructions. The compiler also optimizes branches by shortening or removing branches where it can.

Microsoft C Version 4.0 went one step further with block optimizations that used *common subexpression elimination*. This improved code optimization still further. The advantage is the time saved by avoiding recalculation of computations which are used repeatedly in the program.

For example:

```
a = b * (c/d); will evaluate to:
        tmp = (c/d);
        a = b * tmp;
e = f * (c/d); will evaluate to:
        e = f * tmp;
```

Note: depending on the context, tmp might be a register variable rather than a memory location.

The next progression for block optimizations is to do *loop optimizations* in our future production-quality compilers. If a calculation inside a loop does not depend on any calculations inside the loop, it can be moved outside the loop. This is called *invariant code motion.* A second loop optimization technique is called *induction variables.* This means that while in a loop, multiplies by the control variable can be turned into additions.

Examples of *induction variable* optimization:

```
1.  for (i = 0; i < 10; ++i)
            j+=i * 7;
    evaluates to:
    for (i = 0; i < 70; i+=7)
            j+=i;

2.  char a[10];
            for (i = 0; i < 10, i++)
                    a[i] = 'c';
    evaluates to:
            memset (a, 'c', 10);
    ie: the following 8086 instruction would be generated:
            REP        STOSB
```

There is also *loop enregistering*, in which case calculations can be kept in a register for the whole loop. Loop optimization is implemented in the new 386 C Compiler in the XENIX® 386 Software Development Toolkit.

For more information on the products and features discussed in the Newsletter,
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LETTERS

ever, the sales people should realize that readers and advertisers alike hold those periodicals in greatest esteem that resist the temptation to sully their reputation by selling "advertorial."

Again, I enjoy your publication. I hope that this letter will help the sales staff realize that readers are indeed perceptive to actions that adversely impact the magazine's reputation.

Harold Winard
Wharton, NJ

Yes, it's a fine mess. We know that Microsoft runs the newsletter next to Product of the Month, but we forgot to check its content that month. We did not realize the company would feature QuickBASIC. All we can say is that Microsoft also did not know we would feature QuickBASIC, because our policy is, and always has been, not to notify the vendor in advance when its product has been named.

We normally catch this kind of problem. This time, we did not.

—WF

EMULATE-STRAIGHT

I read with great interest your article entitled "LAN Gateways," (Art Krumrey and Roger Addelson, November 1986, p. 74). However, one slight mistake in the article regarding nomenclature served to confuse me greatly.

The authors continually referred to the "IBM 3270-PC Emulation Program(s)." Of course, IBM does make a machine called the IBM 3270-PC, but I do not believe that this is the product that Messrs. Krumrey and Addelson were using as their test vehicle.

Of course, IBM's nomenclature leaves something to be desired, but that is a subject for another day.

The article, as a whole, was very informative. There are many of us out here in the SNA/SDLC world who are trying to come up with the optimum way to network the myriad of devices that seem to have sprung up in the last few years. Please give us more of these articles in the future.

Paul Sligar
Matsushita Electric
Corporation of America
Norcross, GA

The product reviewed is indeed the IBM PC 3270 Emulation Program, version 2.0. It is a member of IBM's family of 3270 PC Emulation Programs. PC Tech Journal *regrets the error.*

—JS

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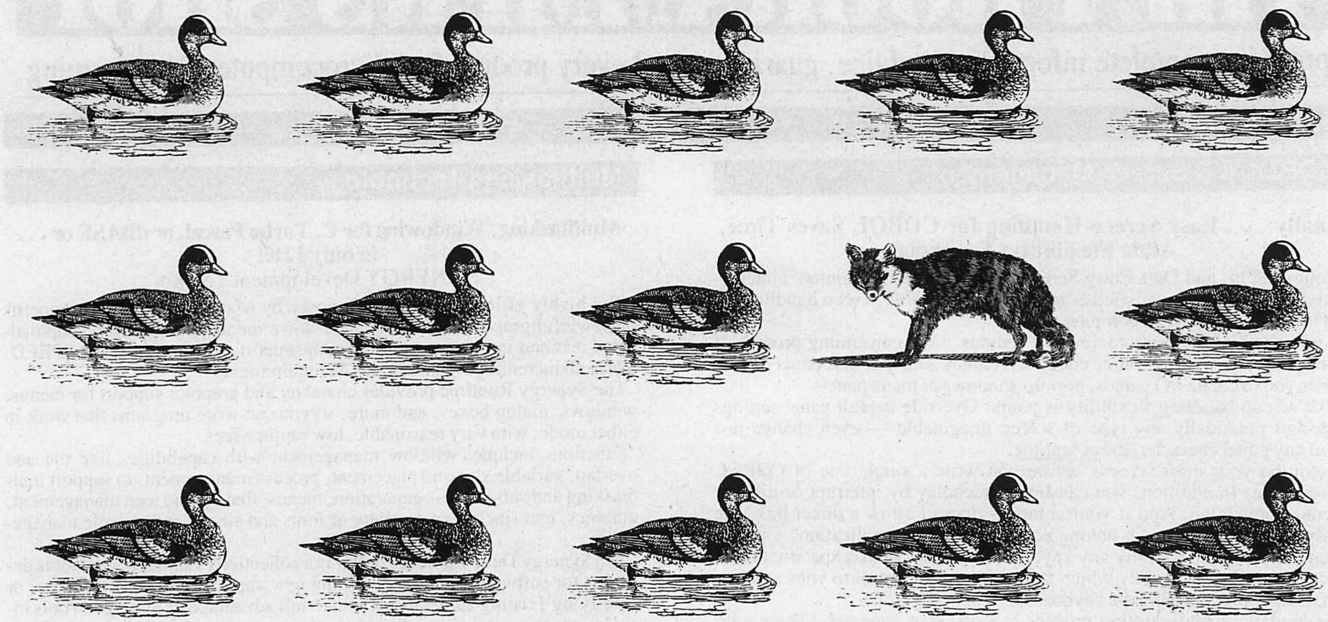

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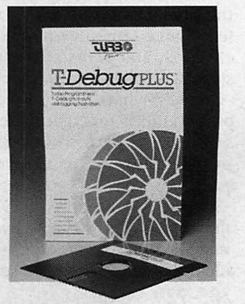

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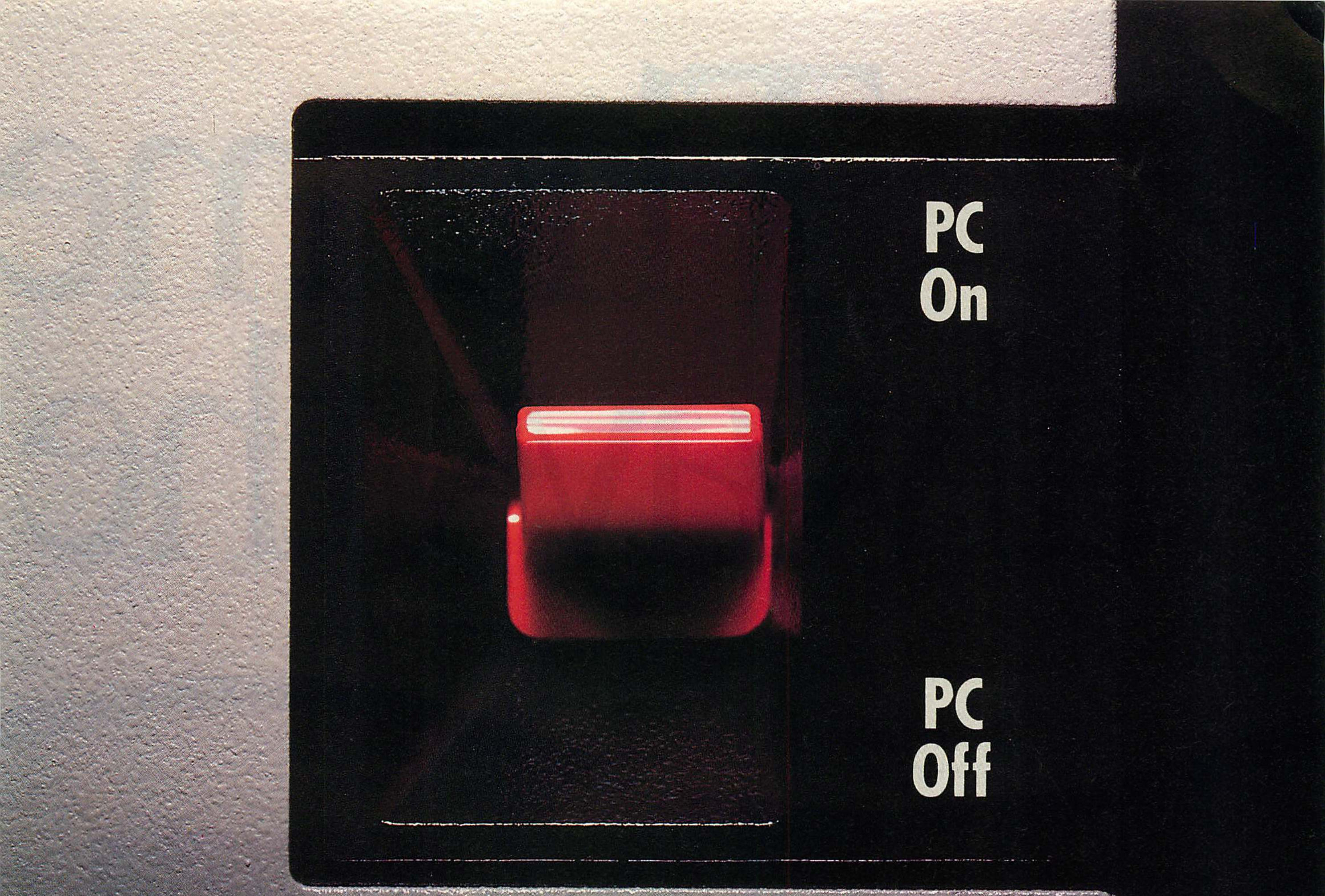

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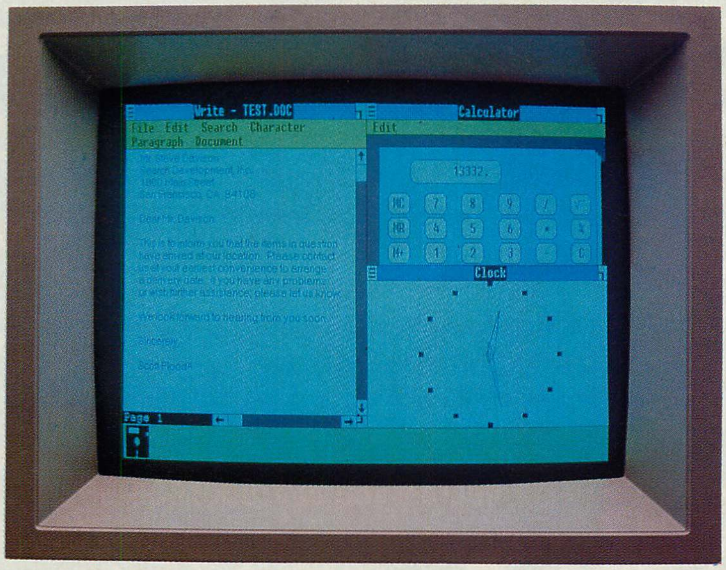
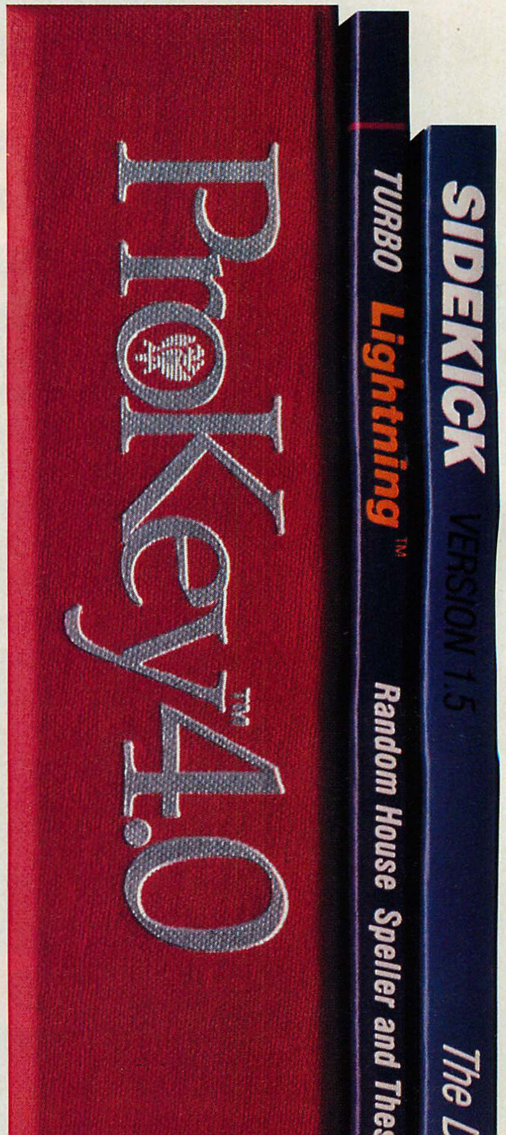


–320K. Windowing can give you a whole new outlook. It can also gobble up a whole lot of memory.



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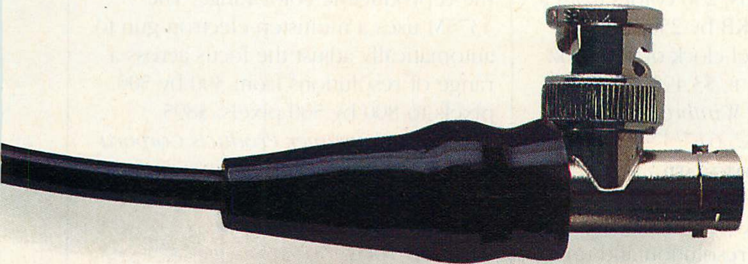
mory is first to go.



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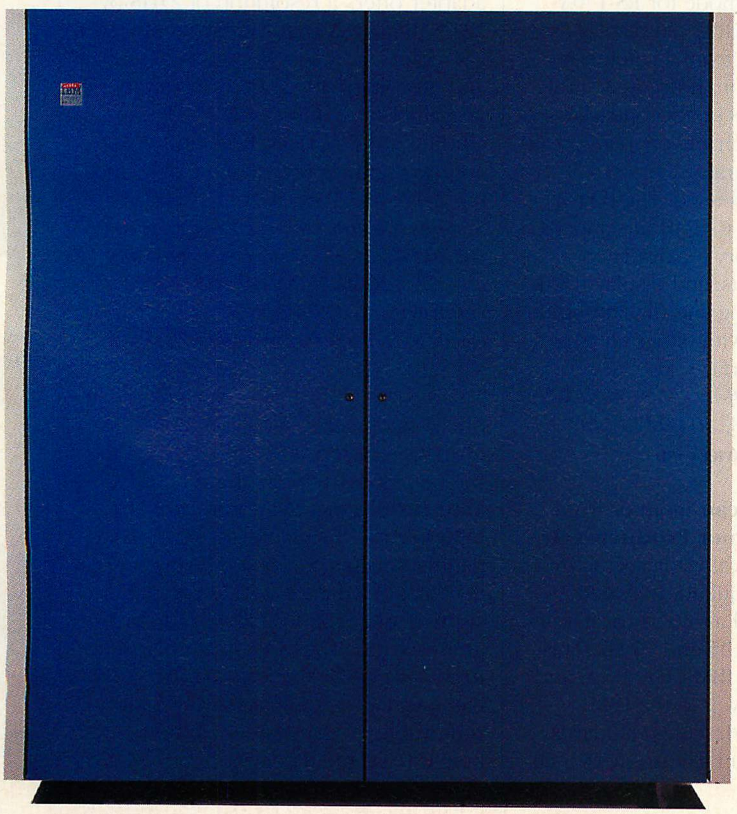

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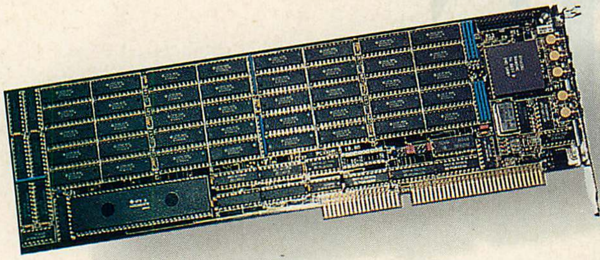
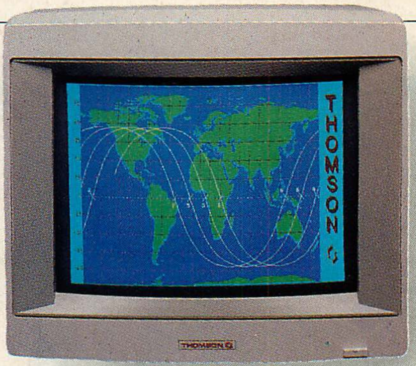


Modgraph, Inc.'s PERFORMER II graphics controller



Thomson's 4375M UltraScan color monitor

HARDWARE

A 16-MHz, 80386 microprocessor-based system, **PC's Limited 386^{16}**, has been previewed by **PC's Limited**. The system uses VLSI (very large scale integration) technology, incorporating fewer than 30 chips on the motherboard. The motherboard measures 9 inches by 13 inches and has eight expansion slots (six available). The expansion bus is user-switchable between 8 and 12 MHz. The system's memory architecture features pure static RAM chips for zero-wait-state operation. The PC's Limited 386^{16} base configuration includes 1MB of RAM, a 1.2MB diskette drive, a 200-watt power supply, and an I/O interface card with four video output modes, a mouse port, two serial ports and one parallel port, and a diskette drive controller. PC's Limited will offer the following as options: a 1.44MB, 3½-inch diskette drive; a 150MB ESDI (enhanced small device interface) hard-disk drive with an average access time of 16 milliseconds (ms), and 40MB and 80MB hard-disk drives, each with a 28-ms access time. Prices for the 386^{16} and its options are not yet available. *PC's Limited, 1611 Headway Circle, Building 3, Austin, TX 78754; 800/426-5150; in Texas, 800/252-8336*

CIRCLE 301 ON READER SERVICE CARD

Two high-resolution graphics controllers, the **PERFORMER I** and the **PERFORMER II**, have been announced by **Modgraph, Inc.** Both use the Hitachi ACRTC (HD63484-8) graphics coprocessor. The PERFORMER I, with a 40-MHz pixel clock and a drawing speed of 2 million pixels per second, offers an onboard video memory of 16KB by 256KB for display of 16 colors with resolutions from 640 by 480 to 1,024 by 780 pixels. Primitives include line, circle, ellipse, arc of circle or ellipse, filled rectangle, and polygon. Zoom, pattern operations, and area fills are implemented in the hardware. Video output is RGBI at TTL (transistor-transistor logic) levels. The PERFORMER II offers all the features of PERFORMER I, but with a resolution of up to 1,280 by 1,024 pixels, 256 colors from a palette of 4,096, 40KB by 256KB video memory, and a pixel clock of 110 MHz. PERFORMER I, $1,895; II, $3,495. *Modgraph, Inc., 56 Winthrop Street, Concord, MA 01742; 617/371-2000*

CIRCLE 315 ON READER SERVICE CARD

A high-performance graphics board that provides twice the resolution and up to 100 times the speed of the IBM Enhanced Graphics Adapter (EGA) has been introduced by **Quadram Corporation**. **QuadHPG** is based on the Intel 82786 graphics coprocessor. It supports four resolution modes: IBM Color Graphics Adapter (CGA), EGA, and Professional Graphics Controller (PGC) and a 640-by-480 pixel mode for RS-170A RGB display. QuadHPG can display as many as 256 colors from a palette of more than 16 million. It draws at a rate of 2.5 million pixels per second, displays up to 25,000 characters per second and has an area fill rate of up to 3.75 million pixels per second. The board features from .5MB to 2MB of standard DRAM video memory for display refresh, character fonts, and display list. It supports both analog and digital output and is compatible with either an 8- or 16-bit data bus interface. $1,095. *Quadram Corporation, One Quad Way, Norcross, GA 30093; 404/923-6666*

CIRCLE 310 ON READER SERVICE CARD

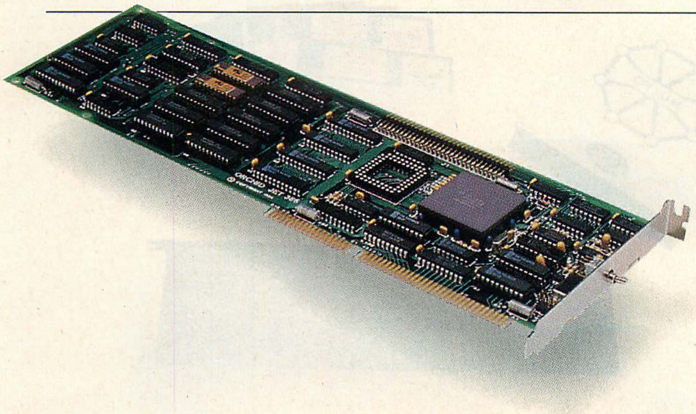
The **4375M UltraScan** monitor from **Thomson Consumer Products Corporation** automatically adjusts to any horizontal scan frequency between 15.7 and 35 KHz, as well as any vertical scan frequency between 45 and 75 Hz. This range supports the IBM CGA, EGA, and PGC standards, as well as the IBM monochrome and Hercules standards. The 4375M UltraScan features a 13-inch diagonal, .31mm-dot pitch tube with high-contrast glass that eliminates glare, thus increasing picture contrast; it also filters color input, thereby improving the reproducible color range. The 4375M uses a multistep electron gun to automatically adjust the focus across a range of resolutions from 300 by 500 pixels to 800 by 560 pixels. $895. *Thomson Consumer Products Corporation, 5731 W. Slauson Avenue, Suite 111, Culver City, CA 90230; 800/325-046; in California, 213/568-1002*

CIRCLE 309 ON READER SERVICE CARD

Systems Manufacturing Technology, Inc. has introduced the **UltraGraph**, a graphics adapter that uses the Intel 82786 graphics coprocessor. The UltraGraph will process graphics at speeds up to 20 million pixels per second. The adapter offers a resolution of 2,048 by 2,048 pixels, 4MB of display memory, 256 colors, and 40-column-by-25-line and 80-column-by-25-line alphanumeric and all-points-addressable modes, including the IBM CGA, EGA, and PGC and two settings between the PGC and the 2,048-by-2,048 mode. $2,500. *Systems Manufacturing Technology, Inc., 1145 Linda Vista Drive, San Marcos, CA 92069-3820; 800/648-6262; in California, 619/744-3590*

CIRCLE 311 ON READER SERVICE CARD

Two workstations designed to merge artificial intelligence with commercial information processing and based on the Intel 80386 have been announced by **Mad Intelligent Systems, Inc.** The **D3000** series is a family of PC/AT-compatible systems and board-level products that use the Intel 82786 graphics coprocessor. The D3000 will run programs written for DOS; it can be configured with UNIX V release 3. The system has seven expansion slots, room for two removable media devices, and one full-height fixed media device. The D3000 is



Orchid Technology's Jet 386 16-MHz accelerator board

9600/V.32 Trellis modem from Cermetek Microelectronics

available in OEM quantities. The **D2000** series is based on a Multibus II architecture; it runs both UNIX V release 3 and Common Lisp. The product line includes a single-user system featuring a high-resolution display with advanced windowing capabilities and a multiaccess knowledge server and a multiuser computer. D3000, $5,000 to $10,000; D2000, prices are not yet available from the company.
Mad Intelligent Systems, 2950 Zanker Road, San Jose, CA 95134; 408/943-1711

CIRCLE 302 ON READER SERVICE CARD

An 80386-based system has been released by **Zenith Data Systems**. The **Z-386 PC** has a 32-bit memory bus and operates at 16 MHz with zero wait states. It features memory paging, burst-mode refresh, which increases system speed by refreshing multiple rows of memory at once; optional cache controller board; and Zenith ROM for video operations (for speed). The Z-386 PC has 10 bus slots (six open), a diskette/Winchester controller, serial and parallel ports, and sockets for 80287 or 80387 numeric coprocessors; it will support two Winchester disks and two diskette drives. Z-386 Model 40 (with 40MB hard-disk drive and 1.2MB diskette drive), $6,499; Z-386 Model 80 (with 80MB hard disk drive), $7,499.
Zenith Data Systems, 1000 Milwaukee Avenue, Glenview, IL 60025; 312/391-8860

CIRCLE 303 ON READER SERVICE CARD

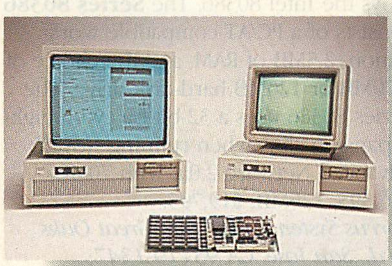
Orchid Technology has introduced **Jet 386**, a 16-MHz 80386 accelerator board. Designed for the PC/AT, Jet 386 is compatible with software written for both the 80286 and 80386. The Jet 386 board replaces the 80286 in the AT, which then plugs into an adapter for the accelerator board. Users can toggle between the two modes. The Jet 386 also supports both 80287 and 80387 numeric coprocessors. A 32-bit bus width and 64KB of on-board cache memory are also included. $1,499.
Orchid Technology, 47790 Westinghouse Drive, Fremont, CA 94539; 415/490-8586

CIRCLE 304 ON READER SERVICE CARD

An 80386 accelerator board for the PC, PC/XT, and PC/AT is available from **Applied Reasoning Corporation**. The **PC-elevATor 386** runs in an 8088, 8086, or 80286 machine. It runs an Intel 80386 at a 16-MHz, zero wait state, with a 32-bit bus, and includes 1MB of onboard, high-speed RAM (100 nanoseconds) expandable to 16MB with daughterboards. An 80287 or 80387 numeric coprocessor can be added. The board installs into a full expansion slot without removing the machine's processor; it works in tandem with the processor, using it to handle I/O. $1,995.
Applied Reasoning Corporation, 86 Sherman Street, Cambridge, MA 02140; 617/492-0700

CIRCLE 305 ON READER SERVICE CARD

Sigma Designs, Inc. has announced **Laserview Display System**, a package that includes a high-resolution adapter



Laserview Display System by Sigma Designs, Inc.

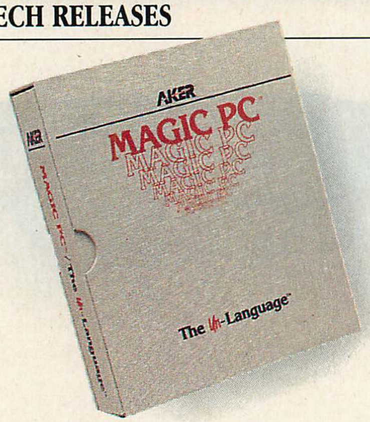
board and a 15-inch or 19-inch monochrome monitor both with a display of 1,664 dots by 1,200 lines. Both are landscape-mount and have paper-white phosphor screens. They feature a scan frequency of 74.5 KHz and a refresh rate of 60Hz, in noninterlaced mode. The resolution provided by the 15-inch and 19-inch monitors is 150 and 110 dpi (dots per inch) respectively. This resolution combines with four shades of gray to produce a perceived resolution that is close to 300 dpi. Adapter with 19-inch monitor, $2,395; with 15-inch monitor, $1,895; adapter alone, $1,150.
Sigma Designs, Inc., 46501 Landing Parkway, Fremont, CA 94538; 415/770-0100

CIRCLE 317 ON READER SERVICE CARD

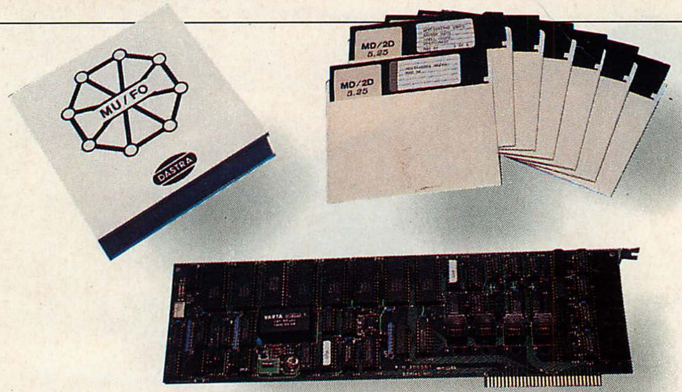
Cermetek Microelectronics has announced its **9600/V.32 Trellis Modem**. The CCITT V.32 specification permits 9600-bps operation at full duplex over a wide range of telephone lines present in the general switched telephone network. The V.32 modem offers synchronous and asynchronous operation. During dialing, the modem can monitor call progress electronically with either verbose or terse prompts, or audibly with a built-in speaker. Another dialing enhancement includes resident nonvolatile memory for ten 40-character telephone numbers. It supports the GSTN (general switched telephone network) and 2- or 4-wire, leased-line operation and offers more reliable data transfer than certain CCITT V.29, 9600 half-duplex modem installations. Trellis coding is a far-end correcting scheme that transmits redundant bit information simultaneously with the data bits. This scheme provides the error correcting and is accomplished without impacting the 9600- or 4800-bps data rate bandwidth. $2,999.
Cermetek Microelectronics, Inc., 1308 Borregas Avenue, Sunnyvale, CA 94088-3565; 408/752-5000

CIRCLE 318 ON READER SERVICE CARD

Two internal modems, the **Quad 1200** and **Quad 2400**, are the first offerings of **Omnitel, Inc.** in its **NetComm** product line. This series is designed for use in LANs and PC-based remote infor-



Magic PC applications generator from Aker Corporation



MU/FO, a multiuser office system from Dastra America

mation and database services. A modem server based on the Quad card provides pooling of 4, 8, 16, or more independently addressable modems for shared access by all LAN users. With a Quad board and a PC/AT, users can set up their own dial-in information services. Quad and dual configurations are available for 1200-bps and 2400-bps speed. The Quad modem board may be used with multiuser systems based on the AT, PC/XT, and the RT PC using XENIX, AIX, PC/IX, or other UNIX software. Quad 1200, $1,249; Quad 2400, $1,799. *Omnitel, Inc., 5415 Randall Place, Fremont, CA 94538; 800/654-2785; in California, 800/233-2202*

CIRCLE 308 ON READER SERVICE CARD

Dastra America's MU/FO is a multiuser office hardware/software package that supports as many as nine users on a single PC/XT or PC/AT. The RAM-resident assembly code operating system allows users to input data, create reports, and perform and develop application programs simultaneously. Three-, five-, and nine-user systems are available. MU/FO contains conversion utilities for Ashton-Tate's dBASE II and dBASE III file importation. Other features include record lockout, automatic backup, and 16 password security levels. In its maximum configuration, the system supports eight terminals and printers, six hard disks, and a tape drive. DOS programs cannot be run concurrently with MU/FO. Prices range from $249 to $1,395. *Dastra America, 976 N. Lemon, Orange, CA 92667; 800/843-5087; in California, 714/633-2275*

CIRCLE 316 ON READER SERVICE CARD

GammaLink has announced that its **GammaFax**, a PC-to-facsimile communications package that enables PC users to send documents directly from PCs to any CCITT group 3 facsimile machine, now offers a high-speed, PC-to-PC file transfer capability. The enhanced GammaFax package allows users to send DOS files, including ASCII documents, over telephone lines at speeds as high as 9,600 bps. GammaFax can route multiple documents in a single transmission, transmit combinations of documents to different sites, store and forward, and broadcast documents to different sites. $995. *GammaLink, 2452 Embarcadero Way, Palo Alto, CA 94303; 415/856-7421*

CIRCLE 312 ON READER SERVICE CARD

FX-BM88 Facsimile Board, an add-on card from **Panasonic Industrial Company**, allows microcomputers to send and receive documents to and from CCITT group 3 facsimile machines. With the FX-BM88, the user can edit and send a file or scanned image to a facsimile machine; a document received from a facsimile machine can be viewed and edited on screen, then output to a dot-matrix or laser printer. $1,000. *Panasonic Industrial Company, One Panasonic Way, Secaucus, NJ 07094; 201/348-7000*

CIRCLE 313 ON READER SERVICE CARD

Corvus Systems, Inc. has announced a high-performance file server that employs the Intel 80386. The **Series 80386** consists of a PC/AT-compatible workstation, 2.5MB of RAM, and the choice of a 70MB or 126MB hard-disk drive. The Series 80386 uses a 32-bit bus with eight expansion slots when running Novell Advanced NetWare 2.0a. With 70MB, $16,595; 126MB, $19,795. *Corvus Systems, Inc., 160 Great Oaks Blvd., San Jose, CA 95119-1347; 408/559-7000*

CIRCLE 306 ON READER SERVICE CARD

PLUS4, an expansion subsystem that allows users to create microcomputer clusters of five users has been introduced by **Alloy Computer Products, Inc.** A complete five-user system built using PLUS4 requires only one host computer equipped with a hard disk and four terminals. PLUS4 includes NTNX Novell-compatible multiuser system software, tape backup, and four Alloy PC-SLAVE/16 boards that provide each user with an individual NEC V20 processor and 1MB of memory. $5,495. *Alloy Computer Products, Inc., 100 Pennsylvania Avenue, Framingham, MA 01701; 617/875-6100*

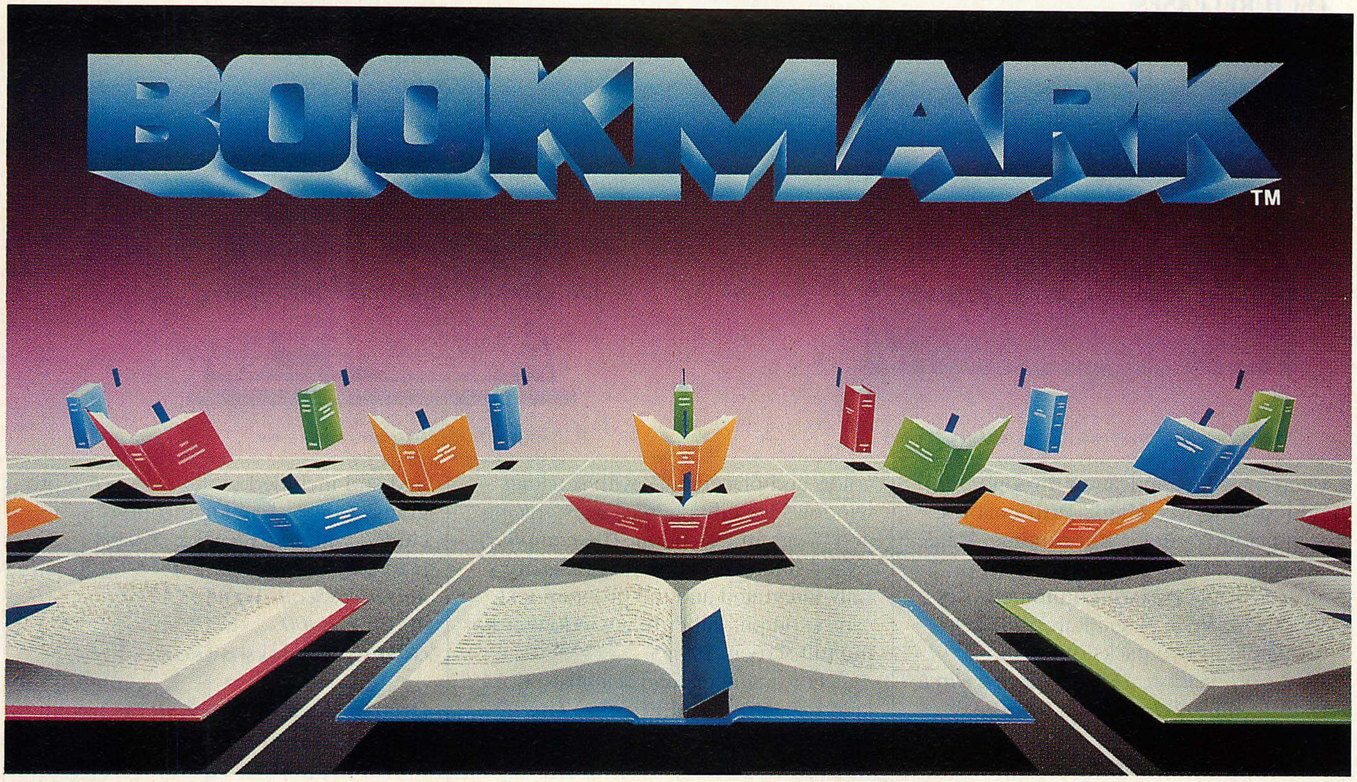
CIRCLE 307 ON READER SERVICE CARD

Epson America, Inc. has entered the laser printer market with the **GQ-3500**. The printer comes equipped with 640KB of memory and has a second generation engine that make possible the compact size of the printer (15.9 by 8.5 by 16.5 inches). The GQ-3500 features a 45-second warm-up time and a first-page-printing time of between 22 and 25 seconds with an overall speed of six pages per minute. Users have access to seven built-in fonts by pushing a button on the control panel. The printer engine's life is rated at 180,000 pages. GQ-3500, $2,495; toner cartridge, $29. *Epson America, Inc., Computer Products Division, 2780 Lomita Blvd., Torrance, CA 90505; 800/421-5426; in California, 213/539-9140*

CIRCLE 320 ON READER SERVICE CARD

SOFTWARE

Aker Corporation has introduced an application generator, called **Magic PC**, that requires no programming language to design applications. The entire process of implementing an application with Magic PC is one of filling in execution tables and data dictionaries. The designer interfaces with these tables by highlighting selections from pop-up, menu-driven windows. Each entry in the execution table is an operation that manipulates data in a true, relational database environment. A zooming capability allows the applications user to probe



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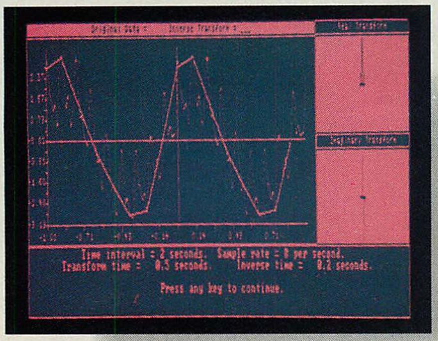


Graph produced by Borland's Numerical Method Toolbox

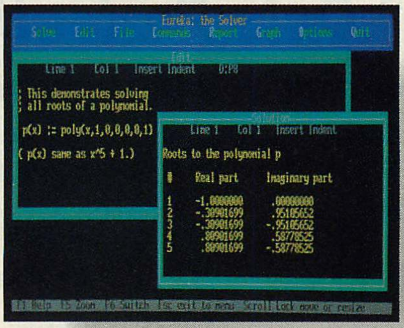
DESQview from Quarterdeck Office Systems

deep into the application through nested windows. **Magic Run** enables stand-alone operation at runtime. Magic PC Trial (limited to 100 records), $19.95; Magic PC (with unlimited users in a LAN), $695; Magic Run, $95 each (available in two-packs only).
Aker Corporation, 18007 Skypark Circle Drive, Suite B2, Irvine, CA 92714; 714/250-1718
CIRCLE 330 ON READER SERVICE CARD

Microsoft Corporation and **Phoenix Technologies Limited** have announced agreements to strengthen Phoenix's custom OEM-level engineering support of Microsoft's systems software, including MS-DOS, XENIX System V/386, and Windows. Under the terms of the agreement Phoenix will develop its 80386-based VP/ix virtual PC environment for Microsoft's XENIX System V/386 multiuser operating system, and license MS-DOS 3.2 from Microsoft and offer it to Phoenix's VP/ix OEM customers as part of the VP/ix offering. Prices are unavailable.
Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 206/882-8080
CIRCLE 325 ON READER SERVICE CARD
Phoenix Technologies Limited, 320 Norwood Park S, Norwood, MA 02062; 617/769-7020
CIRCLE 326 ON READER SERVICE CARD

A BASIC language development environment, **Turbo Basic**, has been announced by **Borland International**. Turbo Basic offers full 8087/80287 numeric coprocessor support, which generates in-line coprocessor instructions. Built-in conversion functions take BASICA floating-point data and convert it to IEEE floating-point format. Programs that use integer mathematics have a 32-bit-long integer data type. Other features include pull-down menus; context-sensitive help; and window management (including user-controllable size, color, and placement), with separate windows for editing, messages, tracing, and program execution. The compiler, editor, and executable programs are fully integrated and the program text can be output either to a window or to the full screen. $99.95.

For engineers and scientists, Borland has introduced **Eureka: The Solver**, a software tool for problem solving. The user writes an equation,



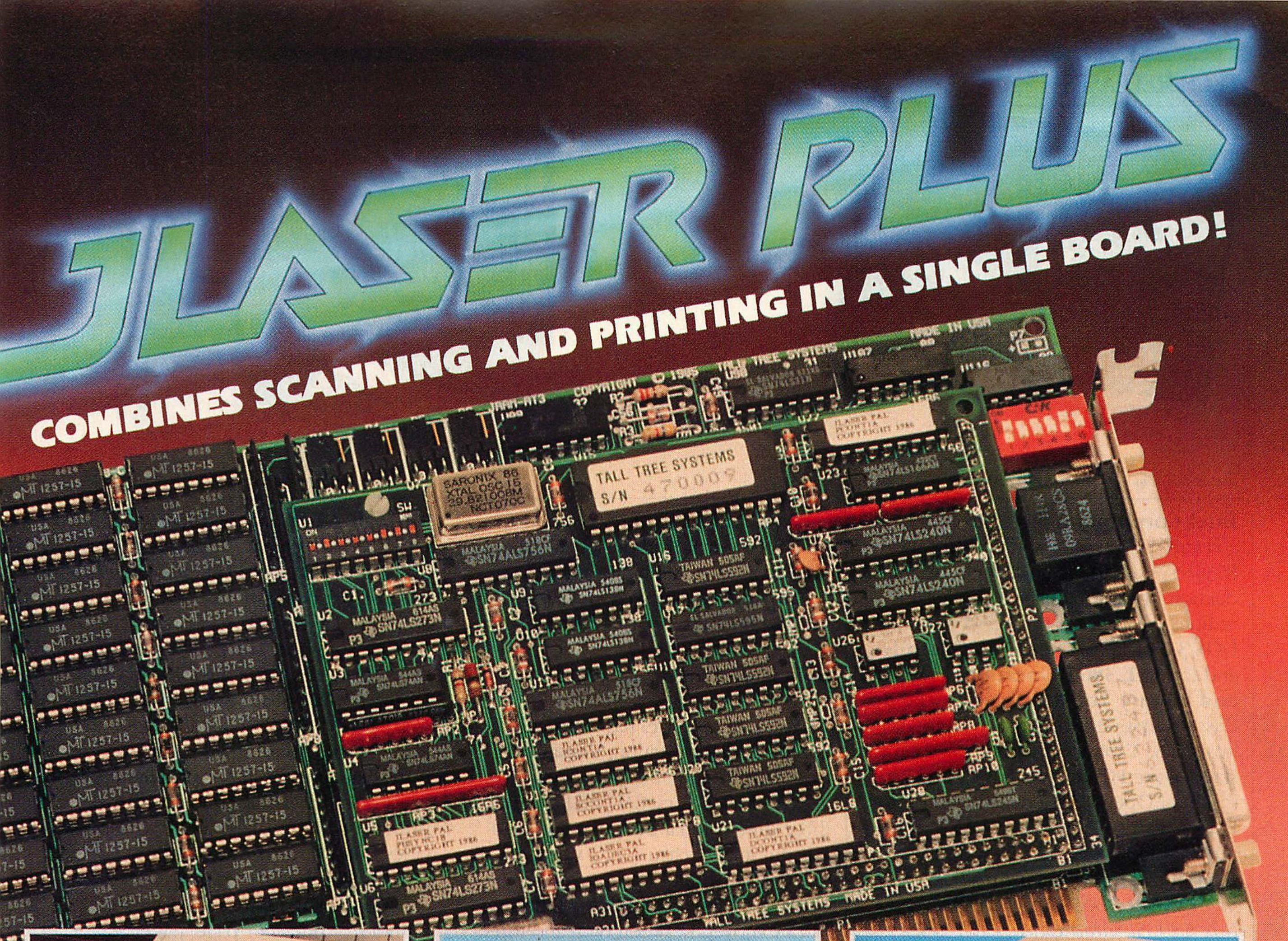
Menu screen from Borland's Eureka: The Solver

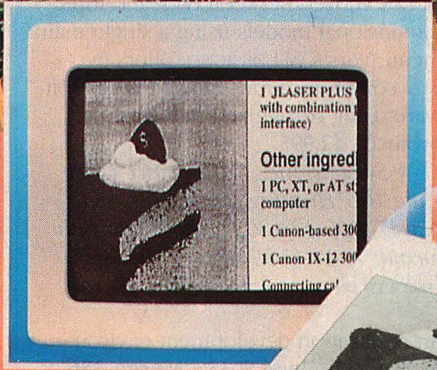
sets options, and instructs the software to solve the problem. The package also evaluates and displays the accuracy of the solution. Equations, solutions, and evaluations are accessible through separate windows on the computer screen. Eureka: The Solver fully supports the 8087 numeric coprocessor. $99.95.

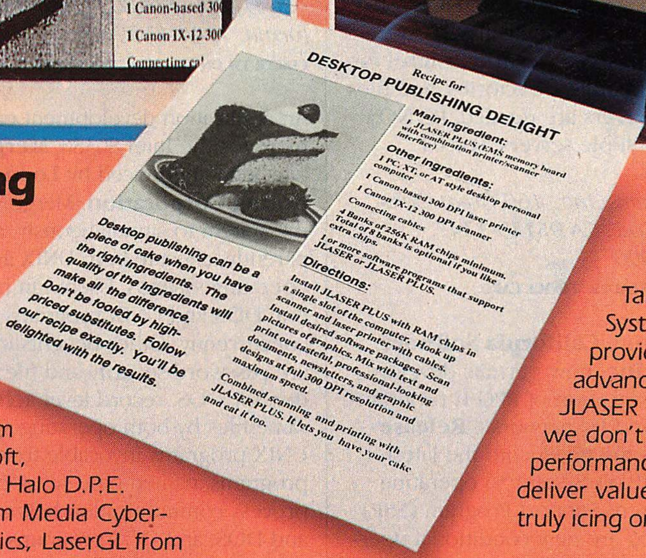
Numerical analysis is addressed in Borland's **Numerical Methods Toolbox**. This package is a collection of Turbo Pascal routines and programs, each with an accompanying demonstration program example. Comprised of 10 modules, the Toolbox provides the following number-crunching abilities: finding solutions to equations, interpolations, calculus with numeric derivatives and integrals, matrix operations including inversions, determinants, eigenvalues, differential equations, least-square approximations, and fast Fourier transforms. The generic procedures contained in each module can be modified and included in the user's own programs. Complete source code is included with the Toolbox. $99.95.
Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066; 408/438-8400
CIRCLE 321 ON READER SERVICE CARD

Quarterdeck Office Systems has incorporated virtual 8086 machine architecture support for the Compaq Deskpro 386 into **DESQview 1.3**, a multitasking operating environment. The virtual-86 mode permits 8088/86 code to be executed within the protected and paged environment provided by the 80386 and permits these programs to run simultaneously, as if they were in their own 1MB machine. DESQview 1.3 also improves the efficiency of high-speed—4800 or 9600 bps—communication programs running in DESQview. To be released in February is **version 2.0** of DESQview, which will increase the capabilities of 1.3 as well as add Enhanced Graphics Adapter (EGA) support and a DESQview Application Program Interface. Also, a runtime version will be available in conjunction with release 2.0. DESQview 1.3, $99.95; 1.21 upgrade to 1.3, $19.95; DESQview 2.0, $129.95; 1.3 upgrade to 2.0, $30.00.
Quarterdeck Office Systems, 150 Pico Blvd., Santa Monica, CA 90405; 213/392-9851
CIRCLE 324 ON READER SERVICE CARD

Version 3.1 of **WATCOM BASIC**, a language interpreter, is now available from **WATCOM Products, Inc.** Enhanced features include: the WATCOM Graphics Kernel System (GKS), indexed file processing, additional capability for parameters of procedures and functions, and several business and scientific program applications. $250.
WATCOM Products, Inc., 415 Phillip Street, Waterloo, Ontario, Canada N2L 3X2; 519/886-3700
CIRCLE 327 ON READER SERVICE CARD







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Supporting JLASER PLUS is a host of software packages, such as PC Paintbrush + from ZSoft, Dr. Halo D.P.E. from Media Cybernetics, LaserGL from Software Express, Ventura Publisher from Xerox, Page Builder from White Sciences, Le Print from Le Baugh Software, Fancy Font and Fancy Word from SoftCraft, Inc., and many more to be announced.

It takes a technological innovator like Tall Tree Systems to provide a major advancement like JLASER PLUS. And we don't stop at performance. We also deliver value, which is truly icing on the cake.

TALL TREE SYSTEMS
1120 San Antonio Road
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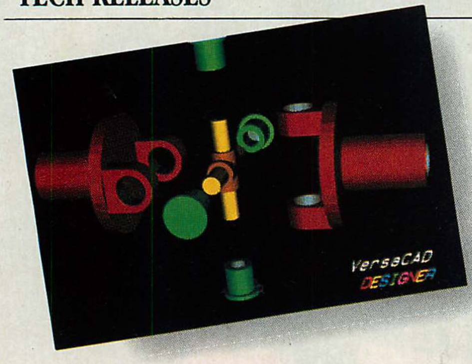

Screen shot from T&W Systems' VersaCAD DESIGNER

LaserControl from Insight Development Corporation

Intel Corporation has extended its software development support of the 80386 system to PC hosts with the introduction of a C language compiler and utilities package for the PC/AT running DOS 3.0 or later. The **C 386 Compiler** and the **RLL 386 Relocation, Linkage, and Library Tools** package are the industry's first development tools for PC hosts. The DOS tools can be used on stand-alone PCs and on PCs linked via the Intel OpenNET network with other PCs or with VAX and MicroVAX+ computers. C 386, $900; RLL 386, $600.
Intel Corporation, Literature Department W338, 3065 Bowers Avenue, P.O. Box 58065, Santa Clara, CA 95052-8065; 503/681-2279
CIRCLE 323 ON READER SERVICE CARD

Corvus Systems, Inc. has released a network operating system for its Omninet LAN. Designated **PC/NOS**, it permits networks to be created without file servers, but still supports the PC-DOS 3.1 file- and record-locking calls. PC/NOS has complete access security control for nodes, peripherals, directories, and files. When file servers are needed, PC/NOS supports multiple servers. For 64 users, $695.
Corvus Systems, Inc., 160 Great Oaks Blvd., San Jose, CA 95119-1347; 408/559-7000
CIRCLE 322 ON READER SERVICE CARD

BABY/36 from **California Software Products, Inc.** now permits development and execution of RPG II programs on the PC and PC networks. **Release 3.4** updates the product to the latest version of IBM's System/36 operating system: System Support Program (SSP) 4.0. Included are new conditional operations and program loops: CASE, DO, DO. . .UNTIL, DO. . .WHILE, and IF. . .THEN. . .ELSE. Stand-alone systems range from $700 for execution-only versions to $3,500 for complete RPG II development and execution systems. LAN versions range from $1,500 to $4,500, plus $100 per linked device; upgrades at no charge to existing customers.
California Software Products, Inc., 525 N. Cabrillo Park Drive, Santa Ana, CA 92701; 714/973-0440
CIRCLE 328 ON READER SERVICE CARD

T&W Systems, Inc. has announced a complete design station, **VersaCAD DESIGNER**. Together with the power of VersaCAD 5.0, VersaCAD DESIGNER offers three-dimensional design, color shading, automatic extrusion, a variety of display modes, built-in primitives, and complete programmability. All designs can be moved between two- and three-dimensional models using a single main menu. VersaCAD DESIGNER offers two-way communications links to other software using recognized standards of protocol. $2,995.
T&W Systems, Inc., 7372 Prince Drive, Suite 106, Huntington Beach, CA 92647; 800/228-2028, ext. 85; in California, 714/847-9960
CIRCLE 331 ON READER SERVICE CARD

An application development environment for the Intel 80386, **Merge 386** has been announced by **Locus Computing Corporation**. Merge 386 allows the system to simultaneously, and transparently, execute both UNIX and DOS operating systems. Users can have several DOS and UNIX programs executing concurrently. Other benefits included are password security and file protection for DOS, record-level access to the same files by both operating systems, UNIX programs invocable from DOS programs, named-pipe support for interprocess communication between UNIX and DOS, and DOS programs transparently invocable from UNIX programs. Merge 386, $500.
Locus Computing Corporation, 3330 Ocean Park Blvd., Santa Monica, CA 90405; 213/452-2435
CIRCLE 335 ON READER SERVICE CARD

Version 2.2 of **LaserControl**, a utility package for Hewlett-Packard laser printers, is available from **Insight Development Corporation**. LaserControl enables the HP LaserJet to work with most IBM PC software. The program provides seven printer emulations: Diablo 630; Qume Sprint 5; NEC 3550, 5510, and 7710; Epson MX-80; and IBM Graphics Printer. This program allows any software that supports these printers to be used with the HP LaserJet. Besides printer emulation, LaserControl provides menu-driven control of the laser printer. Through the menu, users can choose the page layout, fonts, margins, number of lines per page, paper size, paper tray, and other options. LaserControl can be utilized as a memory-resident, pop-up program or a standard DOS application. $150.
Insight Development Corporation, 1024 Country Club Drive, Suite 140, Moraga, CA 94556; 415/376-9451
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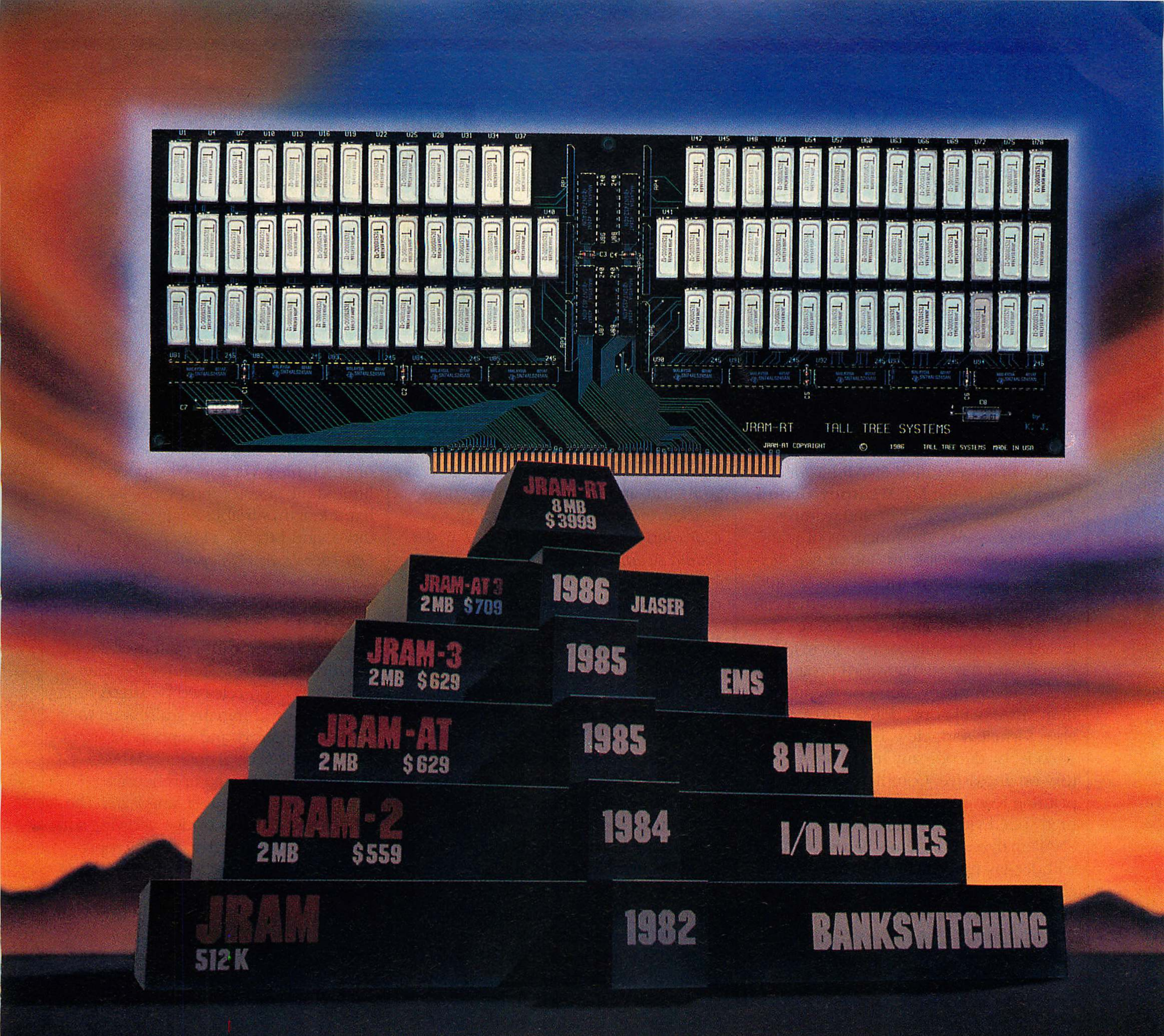
Prospero Software has made available **Pro Fortran-77**, which is a complete implementation of the ANSI X3.9-1978 standard, generally referred to as FORTRAN 77. The software consists of the compiler, runtime libraries, link editor, librarian program, configuration utility, and symbolic debugger. The two-pass compiler converts a source file containing one or more program units into binary machine code in standard Intel object format. Runtime libraries contain the routines needed to support execution of object programs. The libraries are provided in versions for small and large models, with and without the use of an 8087 numeric coprocessor. Pro Fortran-77, $149.
Prospero Software, 190 Castelnau, London SW13 9DH, England; 011-441-741 8531. U.S. Distributor: Software Consulting Services, 3162 Bath Pike, Nazareth, PA 18064; 215/837-8484
CIRCLE 338 ON READER SERVICE CARD



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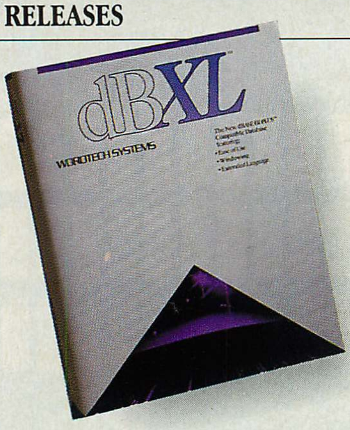
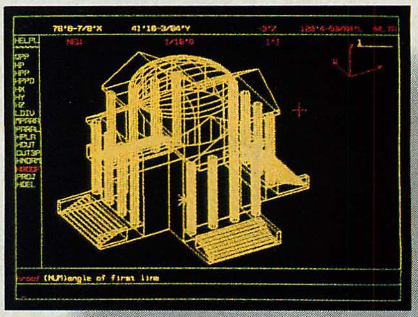


dBXL, WordTech Systems' database manager



Design created using CalComp's CAD package, Solid Vision

A menu-driven, hard-disk-based total system manager called **SNAP** has been introduced by the **Mt. Whitney Group**. This product boasts over 200 features that give the user the functions of many programs executable in one or two keystrokes. SNAP allows the user to create unlimited, customized windows that can be deeply nested. Menus can be selected (alphabetically or free-form), mixed, and moved; password protection can be given to any menu or menu item. SNAP will copy, delete, move, rename, format, sort, view, edit, tag, untag, encode, or decode any file in any directory on any drive. Complete editing and printing features are included as well as high-speed viewing and auto-scrolling. SNAP analyzes a system's hardware and will display more than 35 drive and computer statistics. $99.
Mt. Whitney Group, 11612 Knott Avenue, Building G-19, Garden Grove, CA 92641; 800/992-4992; in California, 800/624-7355
CIRCLE 333 ON READER SERVICE CARD

A true, three-dimensional design and drafting package is being offered by **CalComp Systems Division**. **Solid Vision** allows users to design in three dimensions and revise that design as often as necessary; it also provides the ability to see a design in plan, elevation, section, or perspective and to produce drawings, model design, and presentation images—all from one model. Solid Vision uses boundary representation and boolean technology. All coordinate data are stored in floating-point format, providing six digits of numerical accuracy. Stand-alone, $3,500; bundled with CADVANCE, $4,995.

CalComp also is offering **version 1.3** of **CADVANCE**, a two-dimensional CAD system. Added features include full digitizer tablet menu support, enhancements to CADVANCE's Macro Programming Language, application specific commands, and inclusion of the previously optional 3D PROJECTIONS, which allows the user to produce oblique, isometric, and perspective projections quickly and automatically. $2,500.
CalComp Systems Division, 2411 W. La Palma Avenue, Anaheim, CA 92801; 714/821-2142
CIRCLE 329 ON READER SERVICE CARD

Micro Data Base Systems, Inc. (mdbs) has made available **version 1.1** of its expert system environment, **GURU**. The enhanced expert system capabilities of GURU allow users to process mdbs's KnowledgeMan/2 and Ashton-Tate's DBASE II or DBASE III PLUS files as if they were GURU files. GURU can access Lotus 1-2-3 spreadsheets directly as well. Other enhancements include GURU's knowledge tree and case-saving features. The knowledge tree allows developers to view a diagram of a rule set showing the relationships among variables, rules, and goals. The case-saving feature allows developers to save (and later replay) expert system consultations. Version 1.1 allows multiple firing of rules within the same consultation. Single-user system, $6,500; upgrades at no cost for purchases after November 1, 1985, upgrades for purchases prior to November 1, 1985, $650.
Micro Data Base Systems, Inc., P.O. Box 248, Lafayette, IN 47902; 800/344-5832; in Indiana, 317/463-2581
CIRCLE 334 ON READER SERVICE CARD

Opt-Tech Data Processing has introduced **Opt-Tech Soft 3.0**, a high-performance assembly language sort/merge/select utility. Major added features include record selection, record reformatting, comma-delimited files, support for Ashton-Tate's DBASE III, dynamic memory allocation, alternate collating sequences, expanded file options, unlimited number of input files, and new parameter options. Opt-Tech Sort is callable from 25 languages or can be run as a DOS utility (either stand-alone or batch file). Version 3.0 supports unlimited file sizes of most types including fixed length, variable length, random, DBASE, and Btrieve. $149.
Opt-Tech Data Processing, P.O. Box 678, Zephyr Cove, NV 89488; 702/588-3737
CIRCLE 339 ON READER SERVICE CARD

A version of the THEOS multiuser, multitasking operating system for the Intel 80386 has been released by **THEOS**. **THEOS 386** will initially address up to 16MB of memory and support 32 users in a multiuser environment. THEOS is complemented by comprehensive BASIC, C, and assembly languages. The languages feature a bridge allowing software developed under one microprocessor version of THEOS to be translated and run under newer THEOS versions, including THEOS 386.
THEOS, 201 Lafayette Circle, Suite 100, Lafayette, CA 94549-4370; 415/283-4290
CIRCLE 336 ON READER SERVICE CARD

A work-alike to Ashton-Tate's DBASE III PLUS has been announced by **WordTech Systems**. The **dBXL** database manager, which is not copy protected, offers full file syntax compatibility with DBASE III PLUS and brings new commands to the DBASE language, thus allowing users to create true windows within their programs. Other features include DOS compatibility, an improved user interface, a menu-driven assist feature, and several levels of on-line help. WordTech has assembly code compiler and file server support for dBXL. $169.
WordTech Systems, Inc., P.O. Box 1747, 21 Altarinda Road, Orinda, CA 94563; 415/254-0900
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apl language

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APL*PLUS/PC Tools Vol 2 *by STSC*	85	59
APL*PLUS/UNX *For AT XENIX by STSC*	995	695
Btrieve *ISAM File Mgr by SoftCraft*	245	194
Financial/Statistical Library *by STSC*	275	195
Pocket APL *by STSC*	95	69
STATGRAPHICS *by STSC*	795	579

artificial intelligence

1st-Class *by Programs in Motion*	495	399
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PROLOG Compiler & Interpreter	795	699
Screen Design Toolkit	50	45
SQL Development Package	295	259
Arity PROLOG Interpreter	350	309
Arity Standard Prolog	95	79
AutoIntelligence *by IntelligenceWare*	990	CALL
ExpertEDGE Advanced *by Human Edge*	2500	CALL
ExpertEDGE Professional *by Human Edge*	5000	CALL
Experteach II *by IntelligenceWare*	475	359
EXSYS *Development Software by EXSYS*	395	319
EXSYS Runtime System *New*	600	479
GCLISP *Golden Common LISP by Gold Hill*	495	CALL
GCLISP 286 Developer *by Gold Hill*	1190	CALL
Insight 1 *by Level Five Research*	95	75
Insight 2+ *by Level Five Research*	485	379
Intelligence/Compiler *IntelligenceWare*	990	749
Logic-Line Series 1 *by Thunderstone*	90	85
Logic-Line Series 2 *by Thunderstone*	125	115
Logic-Line Series 3 *by Thunderstone*	150	139
LPA microPROLOG *by Prog Logic Systems*	99	89
with APES	149	129
LPA Professional microPROLOG	395	339
with APES	650	469
Microsoft LISP *Common LISP*	250	163
MPROLOG Language Primer *LOGICWARE New*	50	45
MPROLOG P500 *by LOGICWARE New*	495	395
MPROLOG P550 *by LOGICWARE New*	220	175
PC Scheme *by Texas Instruments*	95	85
Personal Consultant Easy *by TI*	495	439
Personal Consultant Plus *by TI*	2950	2599
Personal Consultant Runtime	95	85
PROLOG-2 Interpreter *by ESI*	450	419
PROLOG-2 Interpreter and Compiler	895	839
QNIAL *by NIAL Systems*	375	349
TransLISP *from Solution Systems*	95	CALL
Turbo PROLOG Compiler *by Borland Intl.*	100	65

assembly language

386 ASM/LINK *Cross Asm by Phar Lap*	495	CALL
8088 Assembler *w/Z-80 Trans by 2500 AD*	100	89
ASMLIB *Function Library by BC Assoc*	149	129
asmTREE *B-Tree Dev System by BC Assoc.*	395	339
Cross Assemblers *Various by 2500 AD*	CALL	CALL
Microsoft Macro Assembler	150	95
Norton Utilities *by Peter Norton*	100	59
Turbo EDITASM *by Speedware*	99	84
Uniware Cross Assemblers *Various by SDS*	295	249
Visible Computer: 8088 *Software Masters*	80	65

basic language

BetterBASIC *by Summit Software*	200	129
8087 Math Support	99	75
Btrieve Interface	99	75
C Interface	99	75
Run-time Module	250	169
EXIM Services Toolkit *by EXIM*	CALL	CALL
Finally *by Komputerwerks*	99	85
Inside Track *from MicroHelp*	65	51
MACH 2 *by MicroHelp*	75	61
Microsoft QuickBASIC	99	65
87 QB Pak *by Hauppauge New*	69	59
Peeks 'n Pokes *from MicroHelp*	45	37
Professional BASIC *by Morgan*	99	75
8087 Math Support	50	42
Stay-Res *by MicroHelp*	95	85
True Basic *w/BASICA Converter*	200	99
True Basic *w/Converter & Run-time*	295	179
BASICA Converter	50	45
Run-time Module	150	99
Various Other Utilities	50	45
Turbo BASIC *by Borland Intl New*	100	69

blaise products

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Turbo TUTOR	40	28
Turbo Prolog Compiler	100	64
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Word Wizard and Turbo Lightning	150	94

c++

►C++ *by Guidelines w/kernel 1.1 Sale*	195	169

c compilers

68000/10/20 Cross Compiler *by SDS*	595	CALL
C86PLUS *by Computer Innovations New*	497	CALL
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►Datalight Developer Kit *Sale*	99	69
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► *with* LIGHT TOOLS *Blaise. New, Sale*	239	168
DeSmet C *w/Debugger*	159	138
DeSmet C *w/Debugger & Large Case*	209	184
Eco-C *Development System by Ecosoft*	125	83
Lattice C Compiler *from Lattice*	500	275
Mark Williams Let's C Combo Pack *New*	125	99
Let's C *Compiler*	75	57
csd *Source Level Debugger*	75	57
Mark Williams MWC-86	495	289
►Microsoft C *with CodeView Sale*	450	265
►Wizard C Combo *by Wizard Systems Sale*	750	529
► Wizard C Compiler *Sale*	450	299
► ROM Development Pkg *Sale*	350	259

c interpreters

►C-terp *by Gimpel, Specify compiler Sale*	300	199
C Trainer *with Book by Catalytix*	122	87
►Instant C *by Rational Systems Sale*	500	359
Introducing C *by Computer Innovations*	125	CALL
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►C Essentials *by Essential Software Sale*	100	65
C-ISAM *by Informix*	225	195
C to dBase *by Computer Innovations*	150	CALL
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dBx *dBase/C Translator by Desktop AI*	350	314
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Vitamin C *by Creative Programming*	225	CALL
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cobol language

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debuggers & profilers

386 DEBUG *Cross Debugger by Phar Lap*	195	129
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Codesmith-86 *by Visual Age*	145	99
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DSD87 *by Soft Advances*	100	79
MiniProbe *by Atron New*	395	CALL
Periscope I *by The Periscope Company*	295	239
Periscope II *w/NMI Breakout Switch*	145	107
Periscope II-X *Software only*	115	84
The PROFILER *with Source Code by DWB*	125	89
The WATCHER *Profiler by Stony Brook*	60	51

forth language

CFORTH *Native Code Compiler by LMI*	300	229
Forth/83 Metacompiler *Specify Target*	750	599
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PC/Forth+ *by Laboratory Microsystems*	250	199
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fortran language

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Microsoft FORTRAN Compiler	350	204
No Limit *by MEF Environmental*	129	115
PANEL *Screen Designer by Roundhill*	295	215
PLOTHI *by The Librarian*	175	CALL
PLOTHP *by The Librarian*	175	CALL
RM/FORTRAN *Ryan-McFarland*	595	CALL
Scientific Subroutine Lib *by Peerless*	175	138
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lattice products

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with Source Code	200	145
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with Source Code	250	178
dBC *dBase File Manager for C*	250	178
with Source Code	500	356
LMK *Make Facility*	195	139
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RPG II Combo *with SEU & Sort/Merge*	1100	939
RPG II Screen Design Aid Utility *New*	350	309
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with Source Code	500	356

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with PLUS Pkg & CAD Software	189	153
with PLUS Pkg & CAD & Paint	219	179
MODULA-2/86 Holiday Package	199	159
MODULA-2/86 Compiler	89	62
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microport products

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microsoft products

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other languages

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other products

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InformixSQL *for DOS by Informix*	795	639
Instant Replay *by Nostradamus*	90	79
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TECH NOTEBOOK 73

MICHAEL ABRASH

Conditional-jump Macros

Macros can be used to size a conditional jump automatically, in order to aid the assembly language programmer.

The need to work around short conditional jumps is one of the annoyances of assembly language programming for the 808x microprocessor family. Backward conditional jumps spanning fewer than 129 bytes and forward conditional jumps spanning fewer than 128 bytes can be implemented with a single instruction, such as JNZ, but longer conditional jumps require a two-instruction sequence, such as JZ around a long JMP. An optimizing compiler is better than an assembler in the automatic generation of the proper code sequence for long or short conditional jumps as needed, and produces tighter, faster code. With the proper macros, however, automatically sized backward conditional jumps are possible.

The macro in MJNZMAC.ASM (listing 1) generates JNZ if the jump distance is short enough for the 128-byte range of the backward conditional jump to reach the destination. If the distance is too great, a JZ around a JMP is generated. If the jump distance is more than 128 bytes (as calculated from the *end* of the JNZ instruction), the JZ/JMP sequence will be generated; otherwise, the more efficient JNZ instruction (3 bytes shorter and 3 to 12 cycles faster on the 8088) is used.

The MJNZ macro can determine the optimal code sequence for backward jumps only. On the first pass of the assembler, the destination of (and hence the distance covered by) forward jumps is not yet known, whereas on pass two, the destination is known, but any change in the length of the code sequence from pass one causes a phase error. The MJNZ macro handles this problem by treating all forward jumps in the same way—as long jumps via a JZ/JMP sequence. Forward jumps that span more than 127 bytes do not cause an error. To make the code as efficient as possible, the forward jumps should be coded as short ones. If any of the jumps should have been long (more than 127 bytes), the assembler generates an error, and the jumps that are in error can be modified manually to be long.

Another useful conditional jump macro is shown in MLOOPMAC.ASM (listing 2). MLOOP generates a LOOP instruction, if possible, or a DEC CX/JZ/JMP sequence, if the jump range is too great. Again, for forward jumps, the listing creates a long jump to ensure that no errors occur at the time of assembly. This can be modified (as explained above for listing 1) for code efficiency where possible.

One excellent application of conditional-jump macros is in building other macros. When coding macros that contain loops around REPT blocks of variable length or macros that contain conditional jumps to destinations outside the macro code, a long jump range normally is assumed, and the JX/JMP code sequence is used because a short jump might not reach in all circumstances. Conditional-jump macros used within other macros ensure that efficient jumps will be generated automatically whenever possible.

Michael Abrash is a senior software engineer for Orion Industries.

LISTING 1: MJNZMAC.ASM

```
; Input:
;       P1 = label to jump to.
MJNZ    macro   P1
        local   skip_label, skip_label1, skip_label2
ifdef P1
  if (P1 LE $)
    if (($ - P1 + 2) LE 128)
        jnz     P1              ;backward short jump
    else
        jz      skip_label
        jmp     P1              ;backward long jump
skip_label:
    endif
  else
        jz      skip_label1     ;forward jump (pass 2)
        jmp     P1
skip_label1:
  endif
else
        jz      skip_label2     ;forward jump (pass 1)
        jmp     P1
skip_label2:
endif
        endm
```

LISTING 2: MLOOPMAC.ASM

```
; Input:
;       P1 = label to jump to.
MLOOP   macro   P1
        local   skip_label, skip_label1, skip_label2
ifdef P1
  if (P1 LE $)
    if (($ - P1 + 2) LE 128)
        loop    P1              ;backward short jump
    else
        dec     cx
        jz      skip_label
        jmp     P1
skip_label:
    endif
  else
        dec     cx              ;forward jump (pass 2)
        jz      skip_label1
        jmp     P1
skip_label1:
  endif
else
        dec     cx              ;forward jump (pass 1)
        jz      skip_label2
        jmp     P1
skip_label2:
endif
        endm
```

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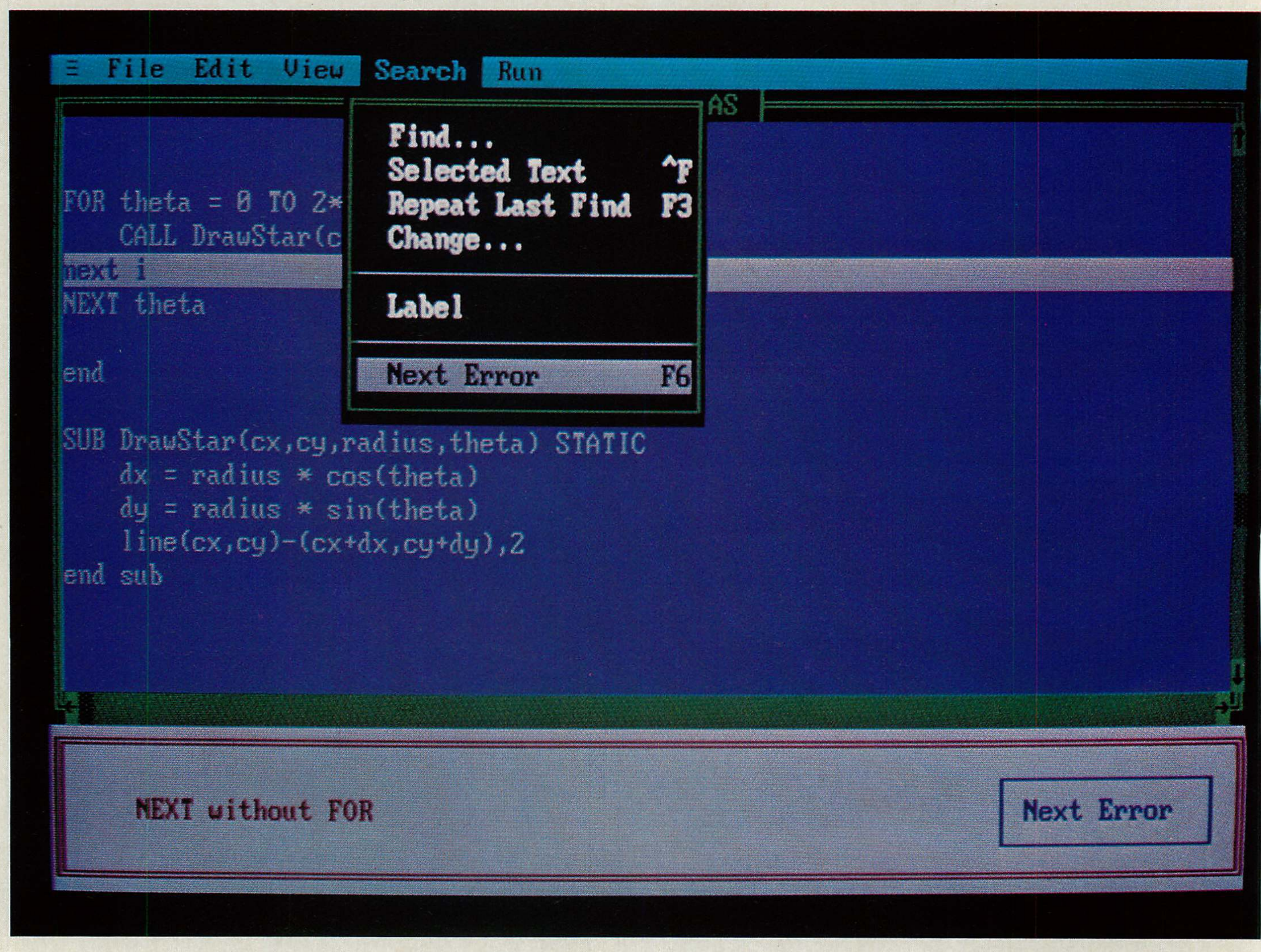

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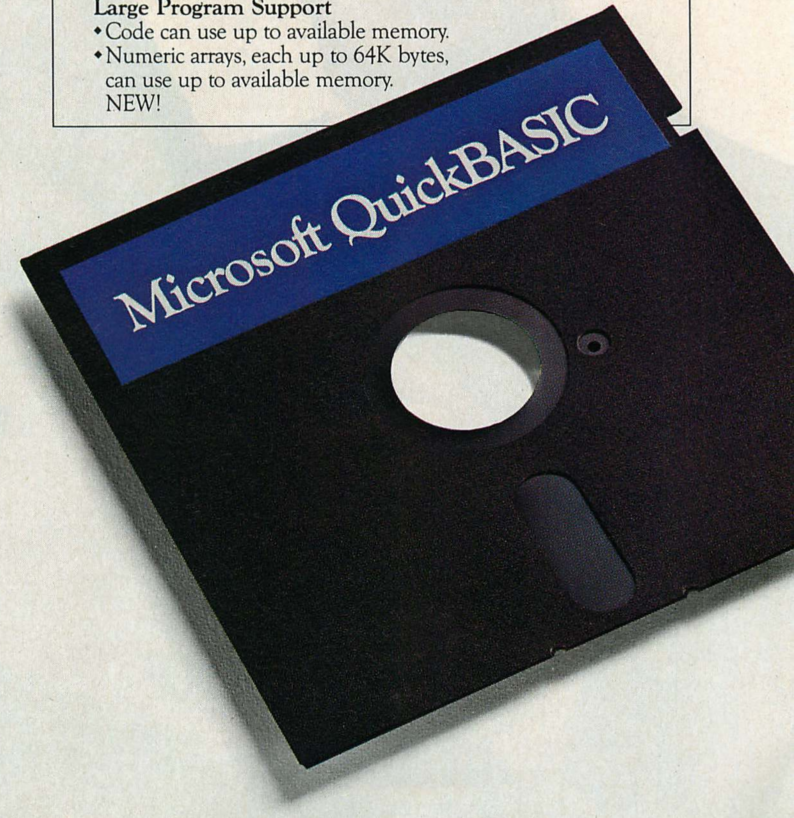

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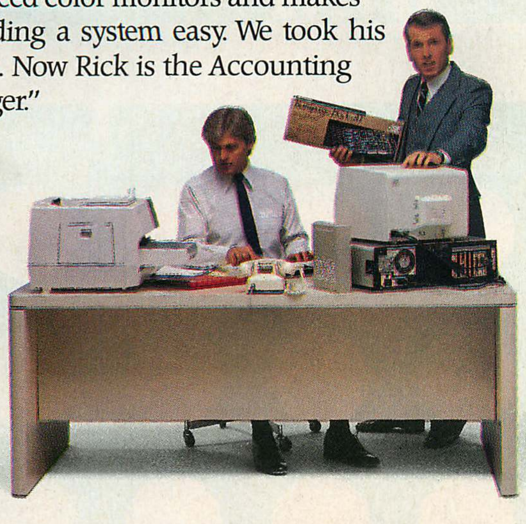

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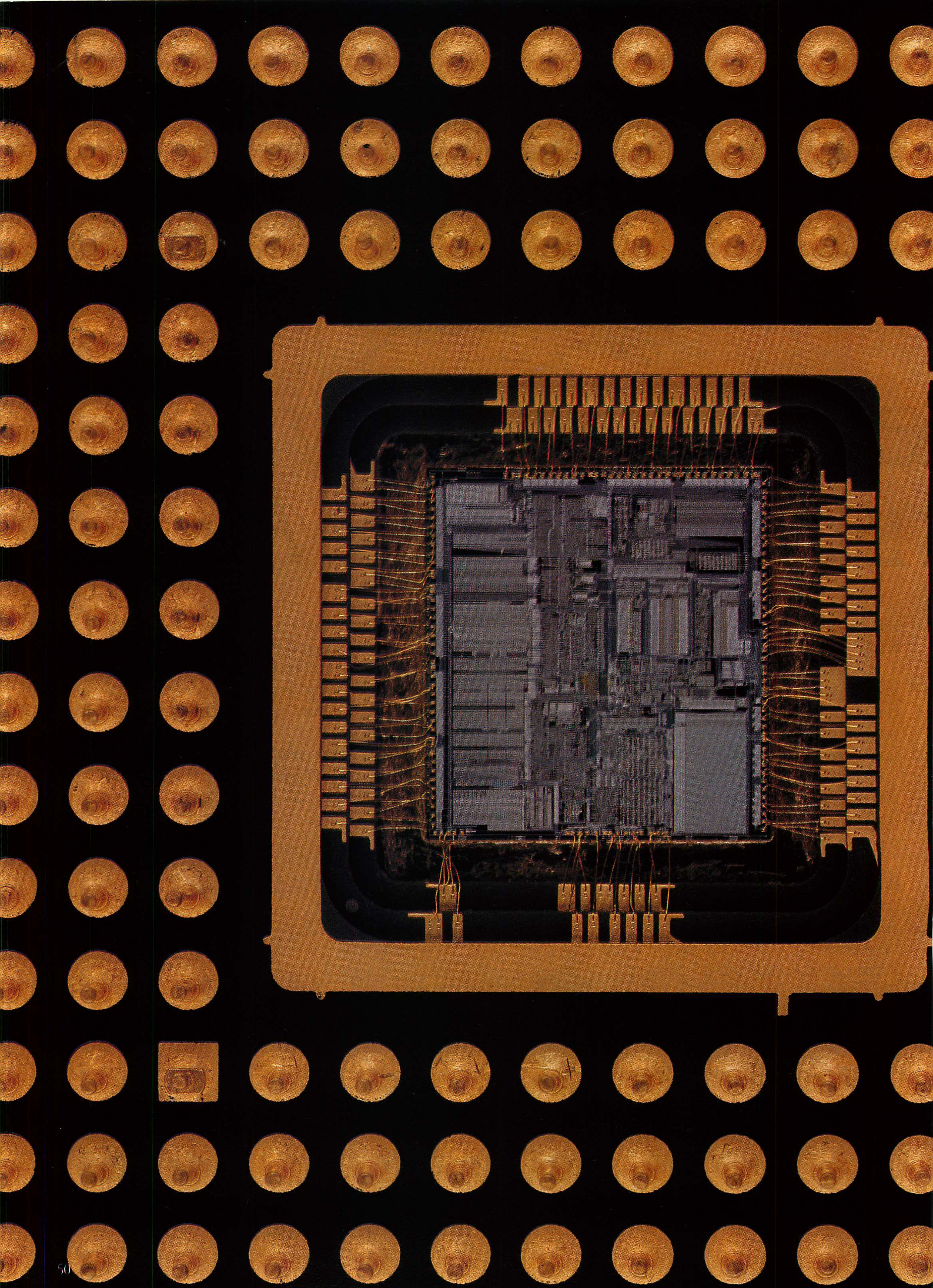

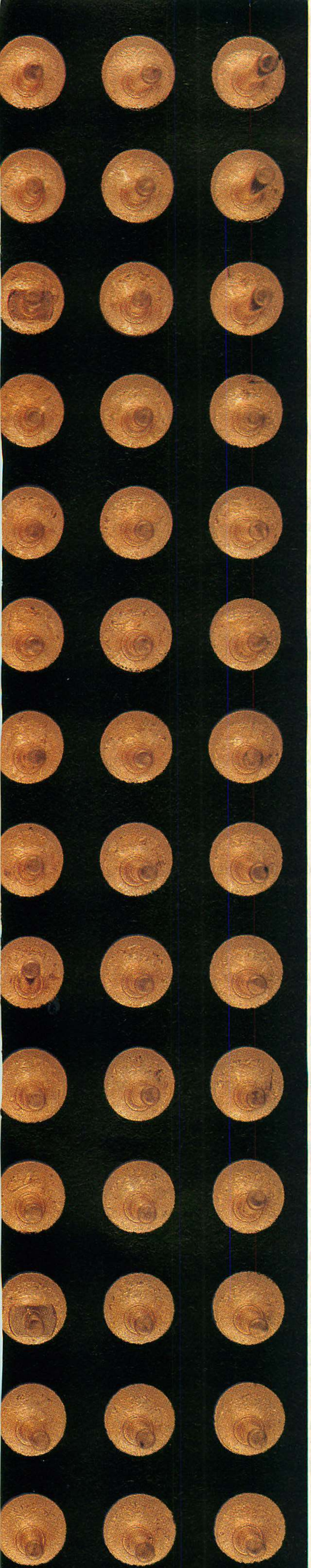

Upward to the 80386

CALDWELL CROSSWY and MIKE PEREZ

The newest microprocessor from Intel builds on the strong foundations of its predecessors to deliver minicomputer performance to the PC.

From its beginnings in the 8086 and 8088, the growth of the Intel processor family has been characterized by full upward compatibility and significant advances in function and performance. While providing functional advances, every new member of the family has retained full instruction set and operational compatibility with its predecessors, affording protection of the investment made on software for the previous microprocessors. In the case of the 8086/88, this investment has been formidable.

It is therefore significant that Intel's latest microprocessor, the powerful 32-bit 80386, brings even greater function and performance while also providing for a smooth transition from the programming environment of the 8086/88 and 80286. This newest Intel family member features internal enhancements, such as instruction and bus pipelining, a larger prefetch queue, and a 32-entry page table cache for memory paging functions, which, coupled with the 16-MHz clock rate, provide a level of performance that is traditionally associated with central processing units in minicomputer products.

The most significant advances of the 80386 are those with the potential for removing the barriers that operating system and application developers have encountered in its predecessors. These new advances include the 32-bit instruction set enhancements, the memory paging functions, the enhanced I/O permission features, and the large linear address (4GB) programming model. Most of all, and most important, is that these advances have been incorporated in a superset manner in order to maintain full compatibility with software products developed for the 8086/88 and 80286. Table 1 summarizes the functional superset provided by each member of the Intel microprocessor family.

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SOLID FOUNDATIONS

The 8086/88 microprocessors are the foundation of industry-standard personal computing. They provide the functional base from which the Intel microprocessor family has continued to evolve in function and performance, and they have set the programming standards used to develop the large number of software products available today for personal computers. However, innovation in the software industry has outgrown the 8086/88 architecture. The performance and function provided by this architecture have become an impediment to the development of more powerful software applications.

The 8086 and 8088 both use a 16-bit internal architecture and provide 16-bit registers and a 16-bit instruction set. The only difference between the two processors is that the 8086 uses a 16-bit external bus to reference memory, whereas the 8088 uses an 8-bit external bus. Their addressing mechanism is a simple one. During program memory references, the contents of the segment register are shifted left by 4 bits and added to the offset to form a 20-bit physical memory address. This address provides software programs with direct access to 1MB of physical memory.

The 8086/88 programming model is based on a segmented memory model in which the code and data portions of a program are partitioned into variable length segments up to 64KB in size. In this model, the 8086/88 microprocessors provide an environment appropriate for developing relatively simple operating systems and applications.

As applications have increased in sophistication, the limits of the 8086/88 architecture have become evident. The 1MB physical memory constraint has forced some applications to resort to complex memory management techniques, such as overlays, that typically place performance and function limitations on those applications. In addition, operating systems with the required functions to support the complexity of new applications have been limited due to the memory size constraints and the direct accessibility of physical memory and I/O devices by applications.

80286 EXPANDS LIMITS

The next step in the evolution of Intel microprocessors was the 80286, also based on a 16-bit architecture, but with significant improvements in the areas limited by the 8086/88. The 80286 provides two different modes of operation: real and protected. In real mode, the 16-bit instruction set, the segmented programming model, addressing mechanism, and 1MB physical memory limitations are identical to those provided by the 8086/88. This compatibility allows most application programs developed for the 8086/88 to execute on the 80286. Execution of these applications in real mode benefits primarily from the faster execution speed offered by the 80286-based computers.

The 80286's protected mode addresses up to 16MB of physical memory and implements a hierarchical memory protection model that is necessary for the implementation of more sophisticated operating systems. Unfortunately, a basic incompatibility between real and protected modes has hindered development of protected mode operating systems that make available to applications the new capabilities of protected mode while also allowing real mode applications to execute.

The protected mode's memory protection model is based on four privilege levels (0 to 3) that can be used to manage access to system memory and I/O devices. Typically, the operating system executes at the highest privilege level (0) and has the ability to access all system memory and I/O resources. Applications, on the other hand, usually execute at the lowest privilege level in which access to memory and I/O resources is limited.

Applications can, however, access operating system and other higher-privilege services that have access to a wider range of system resources by transferring control to those services via *gates*. Gates are used to transfer execution between routines at different privilege levels. For example, call gates can provide access to operating system services that allow applications to access protected system resources indirectly. Other gates—interrupt, trap, and task—are used for interprivilege-level transfers, such as those of execution between tasks and interrupt handlers.

Memory protection is accomplished by assigning to each memory segment a privilege level that is placed in the segment's descriptor entry. This level determines the minimum privilege a program must have to access that segment. An I/O privilege level is also assigned in the flags register to define the level of privilege necessary for a program to perform direct I/O to devices. Combined, the memory and I/O privilege levels assigned to system resources by the operating system define which programs can access these resources.

Similarly, the operating system assigns to each application a privilege level of execution. This privilege level is placed in the least two significant bits of the program code segment (CS) register. Programs that are assigned a lower privilege (higher numerical value) than that required to access a memory segment are prevented by the 80286 from accessing that segment. If such a program attempts to access a memory segment of higher privilege level, a general protection fault (interrupt 0DH) occurs. Similar results occur if a program whose privilege level is lower than that assigned to I/O devices (IOPL) attempts to access an I/O device directly.

By using the least significant bits of the segment registers to contain the privilege level of the executing program, the memory addressing mechanism is made to function differently in protected mode than in real mode. As a result, the vast number of applications developed for the 8086/88 cannot be executed in protected mode and thus cannot take advantage of the increased memory capacity of the 80286.

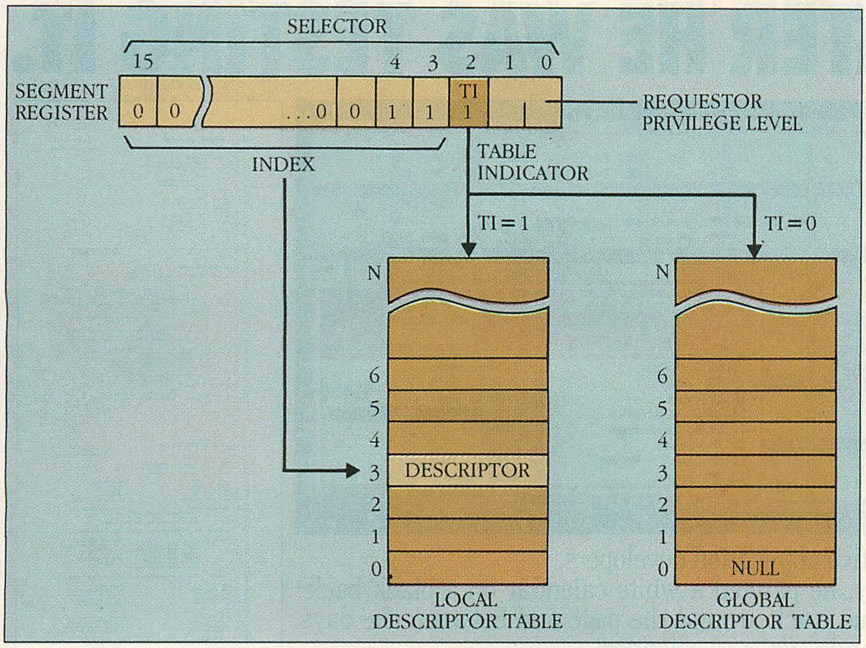
Figures 1 and 2 show the addressing mechanism used in the protected mode of both the 80286 and 80386. In this mode, the content of the segment

TABLE 1: *Intel Family Functional Aspects*

FEATURES	8088/8086	80286	80386
Maximum physical memory	1MB	16MB	4GB
Maximum virtual memory	1MB	1GB	64TB
Maximum segment size	64KB	64KB	64KB or 4GB
Paging hardware	No	No	Yes
Operand sizes (bits)	8, 16	8, 16	8, 16, 32
Register sizes (bits)	8, 16	8, 16	8, 16, 32
Memory-I/O protection	No	Yes	Yes
Coprocessor support	8087	80287	80287/80387
Prefetch queue (bytes)	4/6	6	12

Newer members of the Intel microprocessor family are designed to add functionality and performance while providing compatibility with older family members.

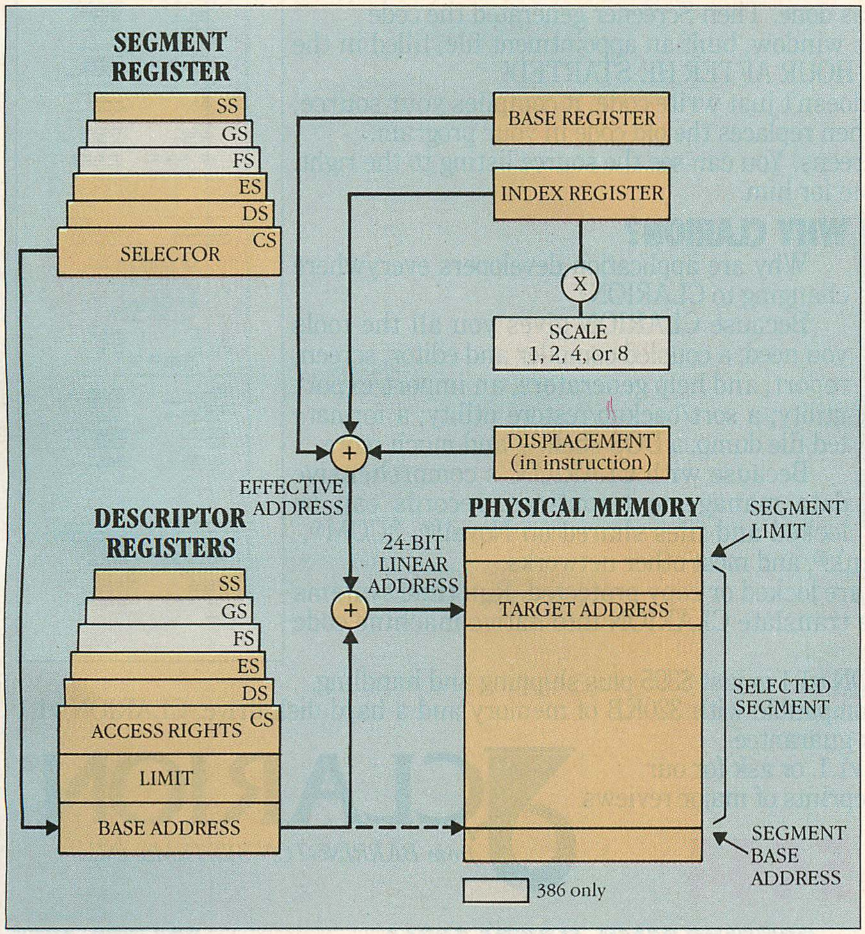
FIGURE 1: *Segment Registers in 80286/80386 Protected Mode*



Adapted from *Intel 80386 Data Sheet*

A 16-bit segment register selects the segment by indexing either the global (GDT) or local (LDT) descriptor table. Typically, each task has its own LDT.

FIGURE 2: *80286/80386 Protected Mode Addressing*



Adapted from *Intel 80386 Data Sheet*

Both the 80286 and 80386 allow addressing through a combination of displacement and base/index registers. The 80386 provides additional segment registers FS and GS and allows the index register to be scaled (multiplied) by 1, 2, 4, or 8.

registers is used, during a memory access, as an index into one of several descriptor tables that define how the physical memory is partitioned in the system. Using the three least significant bits in the segment registers to define the privilege level (0 to 3) and descriptor table (global or local) make the use of the segment register contents incompatible with that of the 8086/88 and 80286 real mode. For example, in the 8086/88, general data, unrelated to segment information, can be stored in the segment registers. Some 8086 programs use their knowledge of segment/offset addressing by placing the value 0 in a segment register. On an 8086, this provides access to the low 64KB of memory. On an 80286 in protected mode, this typically results in a memory protection fault, because the segment register bits have different meanings.

The 80286 also offers task management facilities via the task state segment (TSS) data structure, which allows an operating system to assign a TSS to each task in the system and to store in the TSS the execution state (for example, register contents and flags) associated with that task. The TSS functions make an efficient transition from one task to another by saving the current task's execution parameters quickly in the TSS and restoring the execution parameters of the new task from its corresponding TSS data structure.

A FEW CONSTRAINTS

Powerful applications that have been especially developed to run in protected mode face a number of constraints in the 80286 segmented programming model. For large applications, such as artificial-intelligence-based expert systems, the 64KB segment size limitation forces the developer to partition an application into multiple code and data segments. Thus, the operating system cannot relieve the application (or its source language) from the burden of managing code and data segments.

The segmentation model of the 80286 also hinders the porting of applications developed for microprocessors that use a large linear address programming model, such as the Motorola 68000. Porting such an application to the Intel family would probably require a major redesign of the application in order to partition it into multiple code and data segments.

Other constraints in the 80286 functions have also slowed certain areas of operating system development. For example, the 80286 lacks some of the functions needed to implement an ef-

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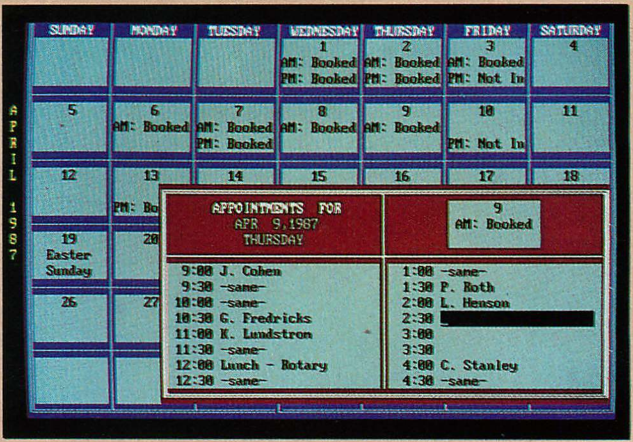

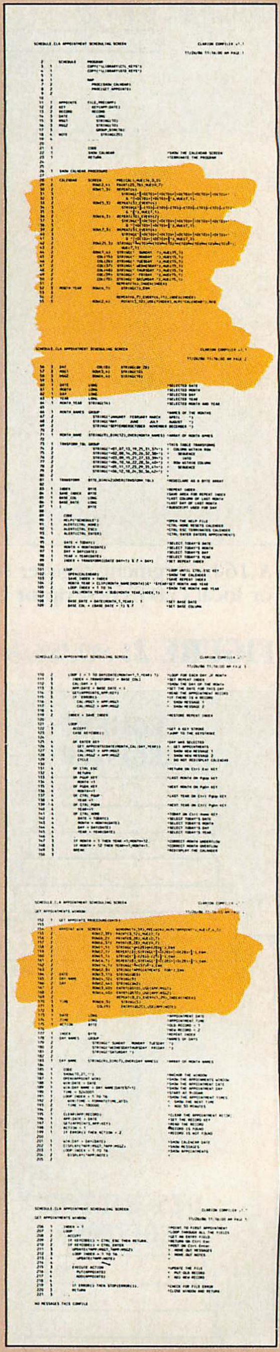

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Then Bob drew the appointments window, built an appointment file, filled in the connecting code and tested it — ONE HOUR AFTER HE STARTED!

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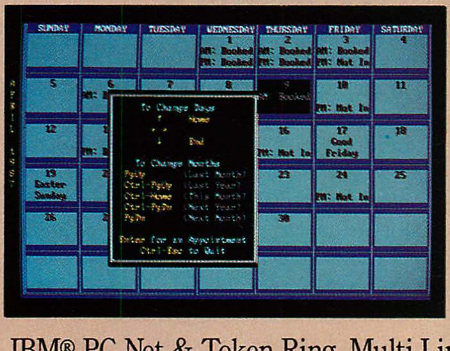

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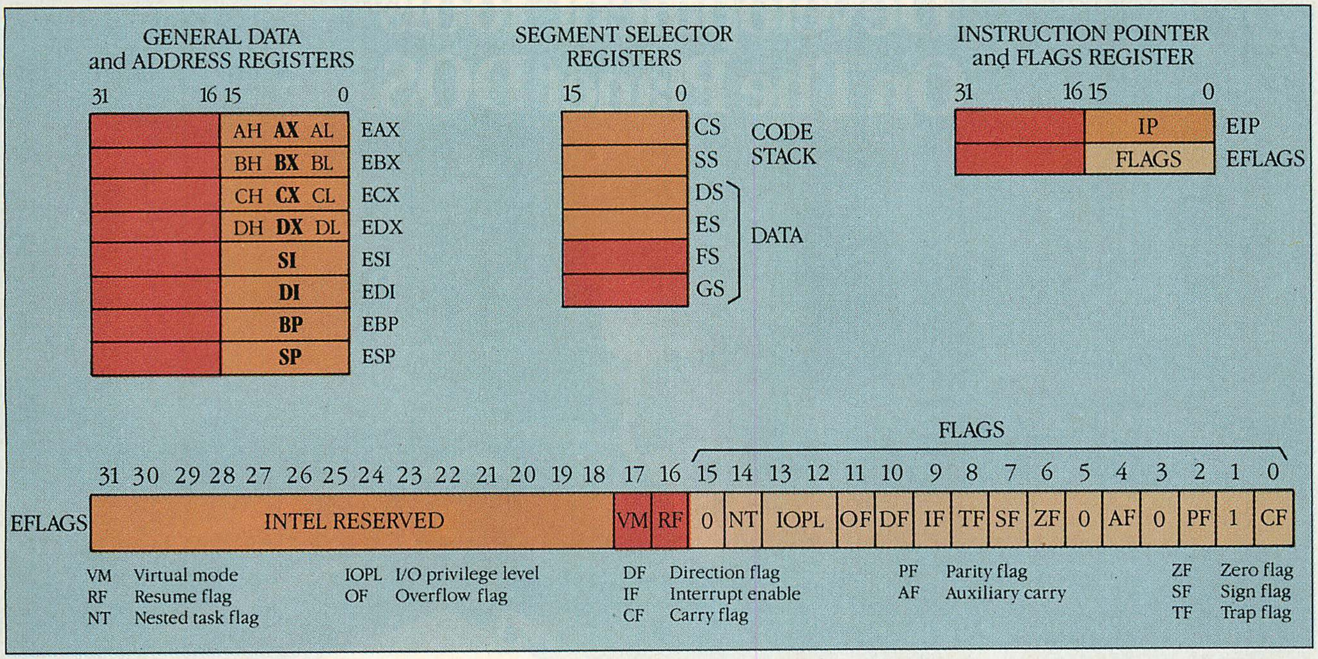
FIGURE 3: *80386 General Registers and Flags*



Adapted from *Intel 80386 Data Sheet*

Most registers are expanded to 32 bits in the 80386. Instruction prefix bytes determine if the 16- or 32-bit register is used.

fective virtual memory system. The advantage of such a system is the ability concurrently to execute single or multiple applications, the total memory requirement of which exceeds the total amount of physical memory installed in the system. Such sophisticated memory management techniques have long been used in mainframe and minicomputer products and are becoming essential for microcomputers. The requirement in certain environments for running multiple applications concurrently has increased the need for these memory management techniques.

STEPPING UP TO 32 BITS

Given these limitations of the 80286, the time seemed right for yet another advancement in microprocessors—and Intel introduced the 80386. It is built on a 32-bit internal and external bus architecture and features a full complement of 32-bit registers (see figure 3), a subset of which can be used to perform 16-bit operations compatible with those of the 8086/88 and the 80286. All 16-bit registers present on the 80286 can be accessed on the 80386 by the same names (AX, BX, etc.). Their 32-bit counterparts are accessed as extensions of the 16-bit registers (EAX, EBX, etc.).

All instruction prefetch operations are made on a 32-bit basis, thus taking full advantage of the bandwidth of the memory bus. As a result of this more effective prefetching method and for optimization with the larger average instruction size, the size of the prefetch queue has been increased from that of previous microprocessors to hold three double words (12 bytes).

The instruction pipelining capability allows the parallel fetching, decoding, and execution of instructions. The execution unit can execute an instruction while the instruction decode unit is decoding the following instruction and the bus control unit is prefetching yet a third instruction. Similarly, for instructions that require memory or I/O bus cycles, the bus control unit can generally perform bus cycles simultaneously with the execution of internal cycles that do not require bus activity.

An example of the efficiency of instruction pipelining is found in the execution of an iteration of the repeat move string (REP MOVS) instruction. An iteration (not the first execution of the repeated MOVS instruction) of this instruction requires four execution cycles and two memory bus accesses (one to read and one to write). In a system with a pipelined zero-wait-state memory architecture, where each 32-bit memory bus access is performed in two cycles, the four bus cycles are performed in parallel with the four CPU execution cycles. The parallel execution of internal and bus cycles yields a 32-bit memory move time of 250 nanoseconds (ns), or four 62.5-ns cycles at 16 MHz.

Bus pipelining is also an important advance of the 80386. It maximizes memory bus activity and allows 80386-based designs to use more cost-effective memory subsystems than equivalent 80286-based systems. With bus pipelining, the 80386 places the control and address signals of the next bus cycle on its external bus while the current bus cycle is still in progress. This allows the memory subsystem to start decoding the next bus operation while the current operation is completing. As a result, the memory control circuitry and memory devices have a longer time to decode memory cycles.

Using bus pipelining, a 32-bit memory access can be accomplished, depending on the speed and design of the memory subsystem, as fast as 125 ns (two 62.5-ns cycles in a 16-MHz zero-wait-state bus operation). This access time compares favorably with the 1 microsecond (16 cycles at 62.5 ns) required to access 32 bits of information via the 8-MHz one-wait-state, 16-bit-bus of typical 80286 computers.

Figure 4 shows the operation of bus pipelining. The memory subsystem indicates to the 80386 via the next address signal (NA#) that it is ready to accept the address and control signals for the second cycle while the first cycle is still in progress (the # symbol indicates the signal is active in its low state). The 80386 places the control (BE0#-BE3#, M/IO#, D/C#, W/R#) and address (A2-A31) signals on the bus and indicates the validity of these signals with a negative transition of address status (ADS#). The memory subsystem uses this transi-

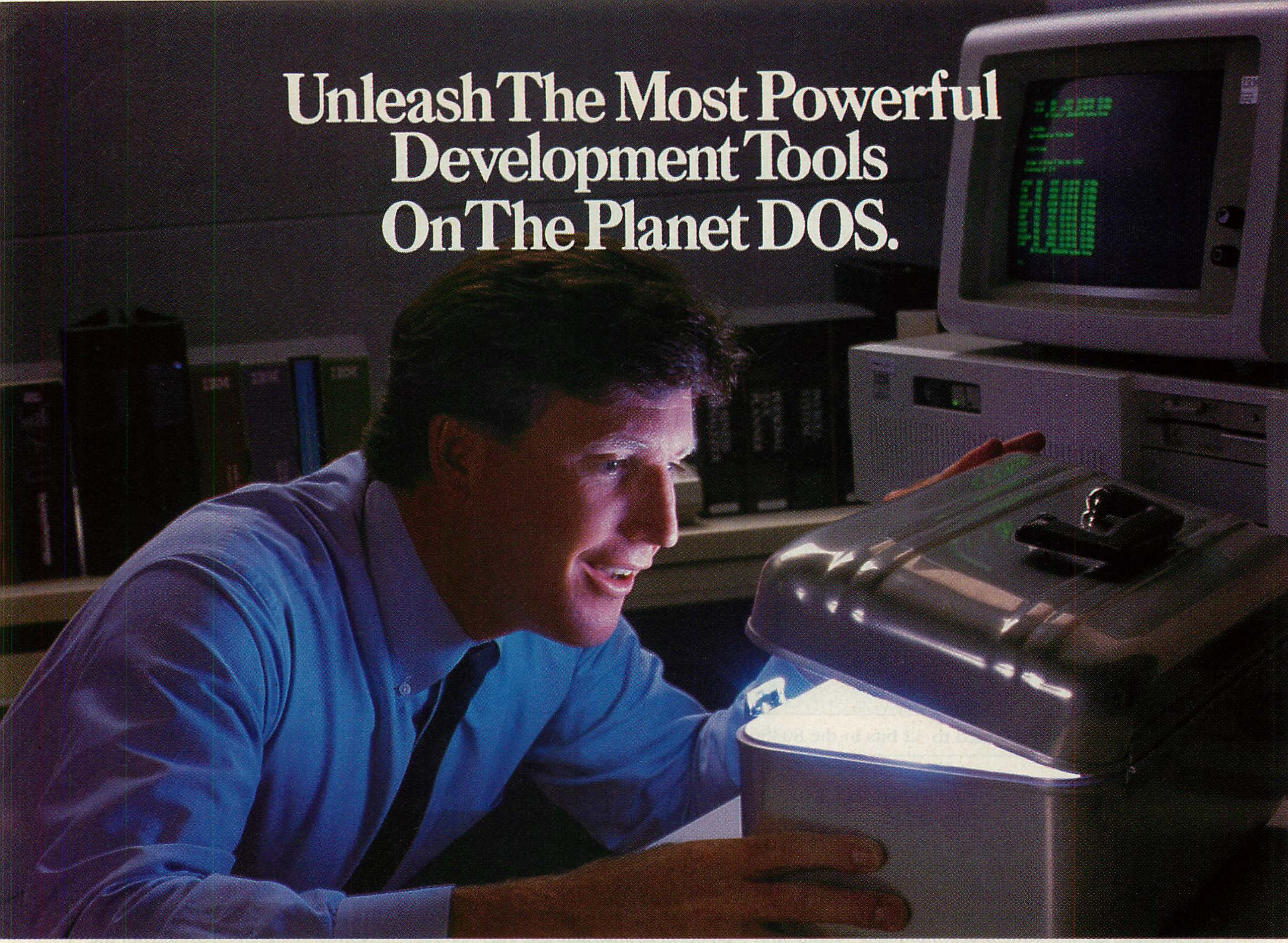


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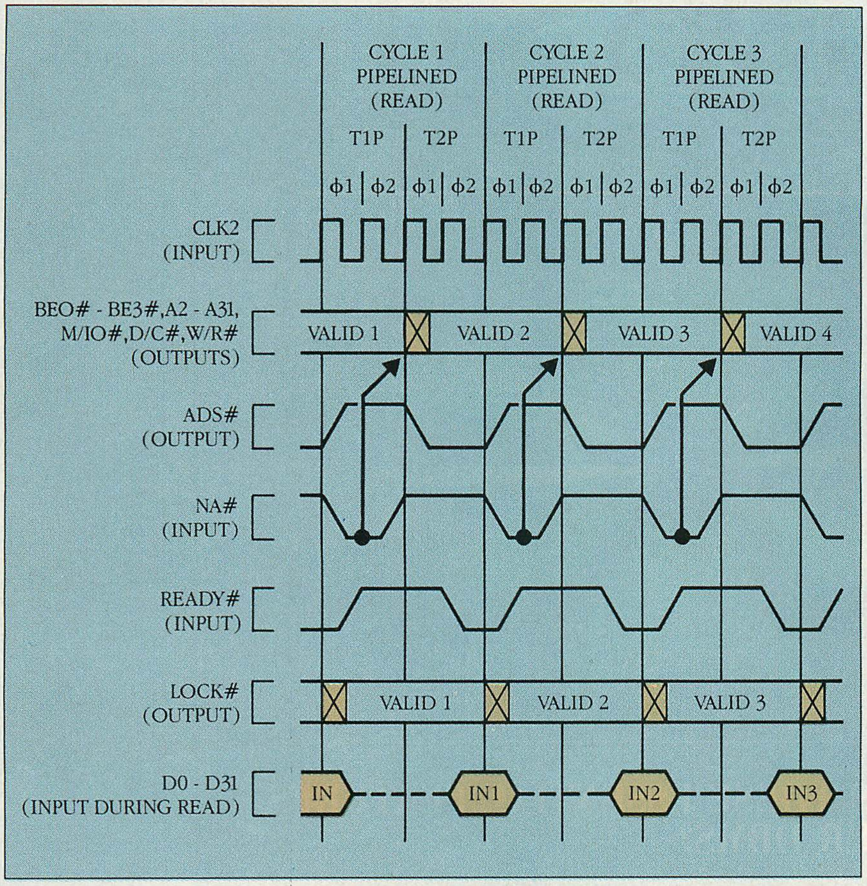
FIGURE 4: *Bus Pipelining Operation*



Adapted from Intel 80386 Data Sheet

A fast memory subsystem can use the next address (NA#) line to overlap the fetching of one operand with the address decoding of the next operand.

tion of ADS# to latch the control and address signals and to start decoding the operation for the next bus cycle (cycle 2). When cycle 1 completes, the memory subsystem then activates the READY# signal to indicate to the 80386 that it is ready to start cycle 2, the address and control signals of which have already been decoded during the execution of cycle 1. Having the decoding already accomplished allows the memory system to complete the memory bus cycle time in two CPU clock cycles.

INSTRUCTION ENHANCEMENTS

The instruction set of the 80386 is a superset of that found in the 8086/88 and 80286 microprocessors. Its highlights are as follows:

- Instructions such as multiply (MUL) have been optimized by using an early-out algorithm in which the most significant bits of the multiplier are 0. This allows a multiply instruction to execute in 0.56 microsecond (that is, 9 cycles * 62.5 ns at 16 MHz).
- The scaled index address mode has been added for instructions using memory references. This address mode permits the contents of an index register to be scaled—that is, multiplied by 1, 2, 4, or 8—before being added to the base. This allows for efficient indexing into data arrays with multiple-byte entries. For example, the instruction

```
MOV EAX, [EDI*8] [EBX]
```

can retrieve into EAX a double word from a data array with its base address stored in EBX. The number of the entry to be accessed (0 = first entry) is stored in EDI with the multiplier, in this case indicating an array with eight bytes per entry.

- A 64-bit barrel shifter in the 80386 execution unit optimizes shift, multiply, and divide operations. With the barrel shifter, multiple-bit shift operations can be executed in one clock cycle. The new shift right double (SHRD) and shift left double (SHLD) instructions use this capability to allow bit string manipulations typically found in BITBLT graphics routines. The SHRD and SHLD instructions use two 32-bit registers to allow a 64-bit string to be shifted multiple positions in a single CPU clock cycle. These instructions allow BITBLT operations to execute on the 80386 in a small fraction of the time possible on the 80286 using multiple shift instructions.
- Support for 32-bit operands and addresses has been added to the instruction set. The 32-bit operand capabilities are available in all modes of the 80386. In real mode, the default size of the operands and addresses is 16 bits, but can be overridden by a prefix byte. This is necessary to maintain full compatibility with programs developed for the 8086/88 and 80286. In protected mode, operand and address size is governed by a bit in the segment descriptor. Use of the 32-bit operands and addresses in each 80386 mode is covered later.

A 4GB IMPROVEMENT

Protected mode of the 80386 features a large linear address programming model. Using this facility, the maximum size of a segment can be increased to 4GB from the traditional 64KB. In this programming model, large applications can reside in a single protected mode segment, thus eliminating the need for the application to manage multiple code and data segments.

Protected mode operating systems such as XENIX/386 provide the linear address programming model to applications. The operating system sets the maximum size of an application segment by specifying a 20-bit segment limit and setting the granularity bit in the segment descriptor (see figure 5). When this bit is set to 0, the segment limit is specified in bytes and yields a maximum segment size of 1MB. Byte granularity is the default value in the descriptor and allows compatibility with programs written for the 80286. When the granularity bit is set to 1, the segment granularity is in pages (4KB per page). This granularity yields a maximum segment size of 4GB.

Intel has added memory paging functions to the 80386 to allow linear addresses (as seen by programs) to be mapped to physical memory addresses. This facility allows the efficient implementation of virtual memory systems.

In virtual memory systems, the operating system creates an environment that allows execution of single or multiple applications that are larger than the installed physical memory. The operating system stores on disk the portions of the application that are least recently used. Then, as code or data portions of the application are needed for execution, the operating system brings

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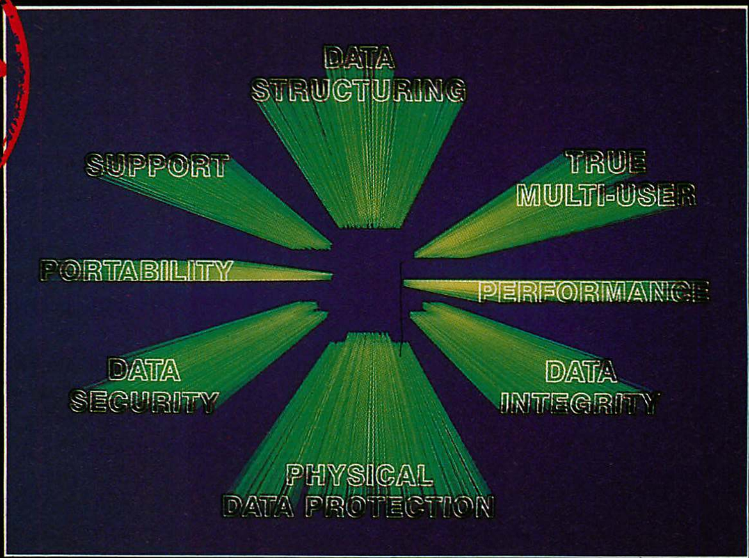

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FIGURE 5: *80386 Segment Descriptor*

31											0	BYTE ADDRESS
SEGMENT BASE 15. . .0						SEGMENT LIMIT 15. . .0						0
BASE 31. . .24	G	D	0	0	LIMIT 19. . .16	P	DPL	S	TYPE	A	BASE 23. . .16	+4

BASE — Base address of the segment
LIMIT — The length of the segment
DPL — Descriptor privilege level: 0 - 3
S — Segment descriptor: 0 = system descriptor; 1 = code or data segment descriptor
TYPE — If system descriptor, TYPE indicates TSS, LDT, or GATE; if code or data descriptor, TYPE indicates reading, writing, or executing privileges
A — Accessed bit
G — Granularity bit: 1 = segment length is page granular; 0 = segment length is byte granular
D — Default operation size (recognized in code segment descriptors only): 1 = 32-bit segment; 0 = 16-bit segment
P — Present bit: 1 = present; 0 = not present
0 — Bit must be zero for compatibility with future processors

Adapted from *Intel 80386 Data Sheet*

A segment's starting memory address, size (up to 4GB), and attributes are all given by its segment descriptor.

them into memory from disk, while restoring to disk the contents of the least recently used portions of memory. This operation occurs transparently to the application, which perceives the entire program as being memory-resident.

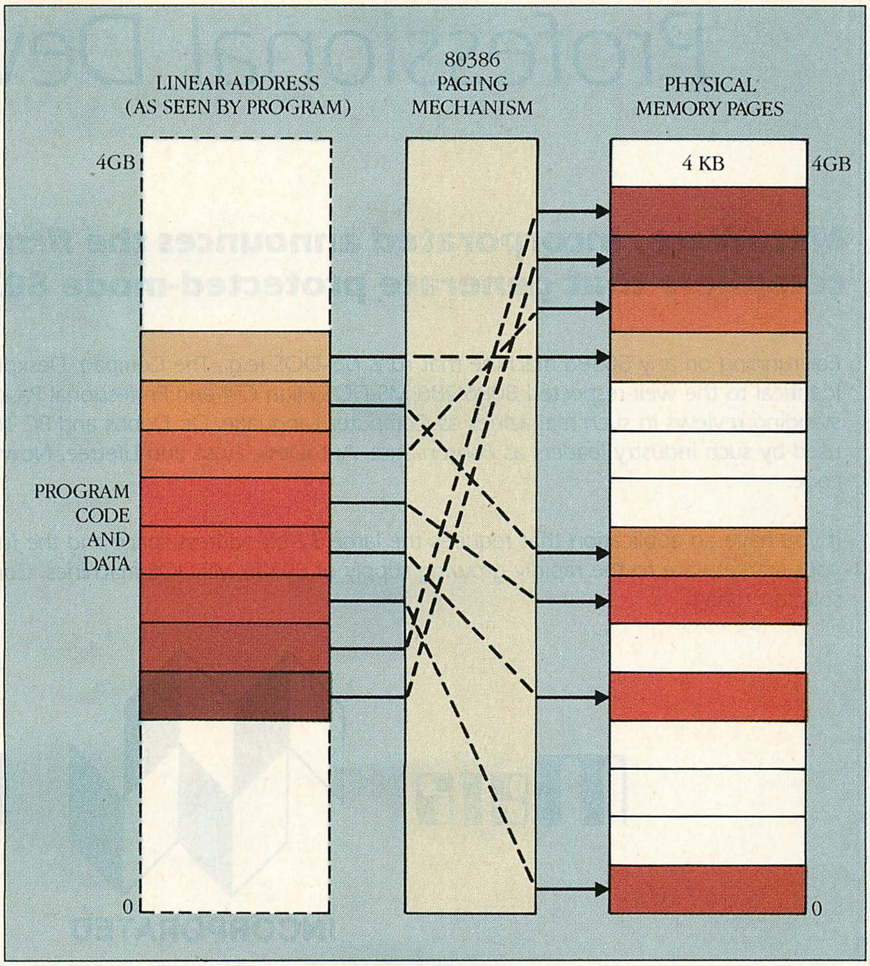
With memory paging support, such as that implemented in the 80386 with a 4KB page size, the operating system can easily allocate contiguous memory to an application simply by mapping a number of noncontiguous physical memory pages into the requested logical program space. This mapping is performed by updating the page directory and tables. Figure 6 shows how the page directory and tables are used to translate the 32-bit linear address that the program sees into a noncontiguous set of physical memory pages.

A set of control registers, shown in figure 7, governs the operation of memory paging. Paging is enabled by setting a bit 31 in control register CR0. Another control register (CR3) is set by the operating system software to point to the location in memory that contains the base of the page directory table. This table, together with the page tables, defines the translation between the 32-bit linear address that is derived from the segmentation model and a 32-bit physical memory address.

The page directory is 4KB in size. This table size allows up to 1,024 page directory entries, each containing the address of a page table. A page table is 4KB and allows up to 1,024 page table entries, each containing the address of a 4KB page frame in physical memory. Figure 8 shows how the memory paging mechanism generates a 32-bit physical address from the 32-bit linear address output by the segmentation unit.

The page table entries also contain bits that are updated by the 80386 in order to help the operating system manage the memory pages. A *dirty flag* is set to 1 by the 80386 whenever a page is written to. This lets the operating system know that the contents of the page have been modified since the last time it was brought in from disk. An *accessed bit* also is set by the 80386 whenever a page is read or written to. This bit allows the operating system to determine which memory pages have been most recently accessed.

FIGURE 6: *Linear to Physical Address Conversion*



Adapted from *Intel 80386 Data Sheet*

The 80386 paging mechanism maps the program's linear address space into physical memory. The operating system decides how pages are mapped.

Another feature that helps the operating system implement memory management functions is the use of the *present bit* in the page table entries. When a page is swapped to disk, the operating system marks the page table entry as not present. If an access occurs to a page that is not present in memory, the 80386 generates a page fault. The

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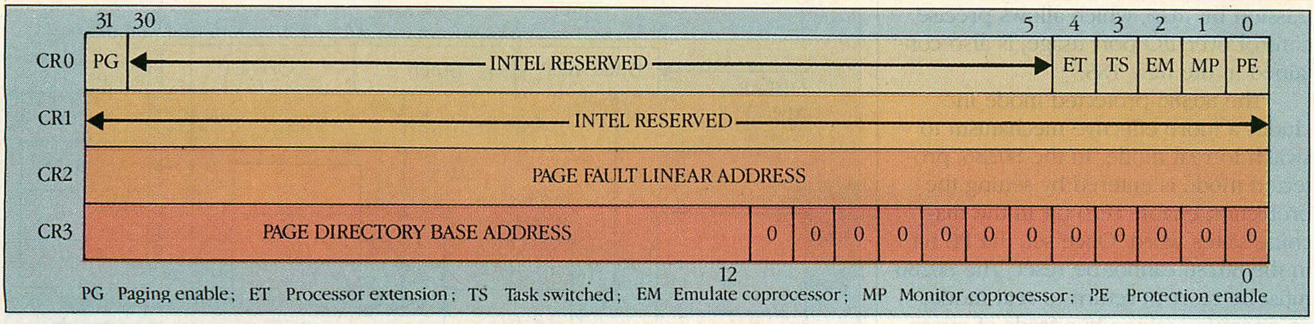
FIGURE 7: *80386 Control Registers*



Adapted from Intel 80386 Data Sheet

CR0 regulates memory management and coprocessor handling. CR1 is reserved by Intel. CR2 is set by the 80386 to the linear address that last generated a page fault. CR3 is the physical address of the page directory, which is always page-aligned.

fault signals the operating system that the page whose linear address is stored in control register 2 should be brought into memory. As the page is brought into memory, the operating system updates the page table entry as present and returns from the page fault to perform the desired memory access.

To support the memory paging functions without accessing the page directory tables on each memory access, the 80386 contains an internal 32-entry cache called the *translation lookaside buffer* (TLB). This cache automatically keeps the address of the 32 most recently used page table entries for speedy look-up during memory accesses. The operating system must flush the contents of the cache whenever a page table entry is marked not present in order to maintain coherency between the cache and the pages present in memory. The contents of the cache are flushed whenever CR3 is written to.

When the TSS data structures are used by the operating system to perform task management functions, the address of the page directory (CR3) associated with a task is saved in its TSS when a task context switch is performed. Because a single page directory entry has the capacity to address a full page table of 1,024 entries (4MB of memory), it is doubtful that an entire page directory would be assigned to each task. A single page directory entry per task should suffice in most cases.

The 80386 offers I/O permission functions that are an extension of the I/O protection level (IOPL) mechanism found on the 80286. The basic IOPL mechanism prevents applications with low privilege levels from accessing any I/O device without the intervention of the operating system. This mechanism has been extended on the 80386 to allow the operating system to specify the I/O devices (I/O addresses) that it wants to protect from direct access by applications. This capability is useful in the 80386's virtual-8086 mode (described later) where it prevents direct access to I/O devices by 8086/88 applications and simulates low-bandwidth I/O devices.

The I/O devices to be protected by an operating system are specified via the I/O permission bit map, a variable length map where each bit corresponds to a byte I/O port address. When I/O operations are performed to a device address whose corresponding I/O permission bit is 1, control is transferred by the 80386 to the operating system via a general protection fault. The operating system then can take the appropriate action to protect or simulate a specific I/O device at the accessed I/O address. The base address of the I/O permission bit map is contained in the active TSS and is automatically saved on a task context switch. Because each task is likely to have access to different devices, each task should normally have its own I/O permission bit map.

MODES OF OPERATION

Real mode is the default mode of the 80386 upon reset. This allows the 80386 to begin execution in a manner compatible with the 8086/88 and 80286. The memory addressing mechanism, 1MB memory limitation, and 64KB-maximum segmented programming model are identical to real mode in the 80286. Most programs written for the 8086/88 and 80286 should run without modification. For a discussion of trouble areas, see the sidebar "Programming Considerations for the Intel Family."

The key distinction between 80386 real mode and that of its predecessors is its support of 32-bit operands and addresses in the instruction set. By using override instruction prefixes for operand size and address size, the 16-bit default nature of instruction operands and addresses can be specified to be 32 bits in size. The specification of 32-bit operands yields significant performance benefits in arithmetic and memory transfer operations. The 32-bit addressing feature is less important in real mode due to the maximum segment limit of 64KB and the 1MB physical address limitation, but it does allow the use of the extended addressing specifications, such as scaled indexing with the full register set available as base and index.

The operand size prefix (66H), when used preceding an instruction in real mode, indicates that the operands to be used are 32 bits. For example, when the instruction MOV AX,BX is preceded by the operand size prefix, the result is an instruction that moves the 32-bit register EBX to EAX. Similarly, the address size prefix (67H) can be used on individual instructions to specify extended addressing and can be used in combination with the operand size prefix. With both the operand size and address size override prefixes, an instruction can be created, such as

```
MOV EBX, [EAX] [ESI*4] ARRAY + 80
```

This specifies a base value (EAX), a scaled index value (ESI * 4), and a displacement (ARRAY + 80) that are combined to form an offset, the 32-bit contents of which are placed into the EBX register. Other improvements are available in 80386 real mode. For more information, see the sidebar "Making the Most of the 80386 Today."

Protected mode in the 80386 offers a superset of the functions found in that mode in the 80286. The privilege-level-based memory and I/O protection system, 8- and 16-bit operand modes, and 64KB-maximum segmented programming model of the 80286 are supported in the 80386's protected mode. In addition, memory paging, large linear address space, and the I/O permission bit map can be used in protected mode.

The TSS, introduced in the 80286, now includes data defined by the oper-

ating system software as well as the hardware registers. The 80386 I/O permission bit map, which allows precise control over I/O port usage, is also contained in the new TSS.

The 80386 protected mode includes a more effective mechanism to switch to real mode. In the 80286, protected mode is entered by setting the protection enable (PE) bit in the machine status word. Once set, the PE bit in the 80286 cannot be reset. The 80286 must be reset to return to real mode, an operation taking hundreds of microseconds. The 80386 can be returned to real mode simply by resetting the PE bit in control register 0.

The 80386 protected mode provides a programming environment fully compatible with that of the 80286; 16-bit protected mode applications can be executed because the segment descriptors function the same as those on the 80286 when initialized for use by programs for the 80286. For example, when initialized for use by such a program, the granularity (G bit) in the segment descriptors (see figure 5) is set to 0, indicating byte granularity. This yields memory segments compatible with the 64KB maximum limit of the 80286. Similarly, the default operation size (D bit) is set to 0, indicating the use of 16-bit operands and addresses equivalent to those of the 80286.

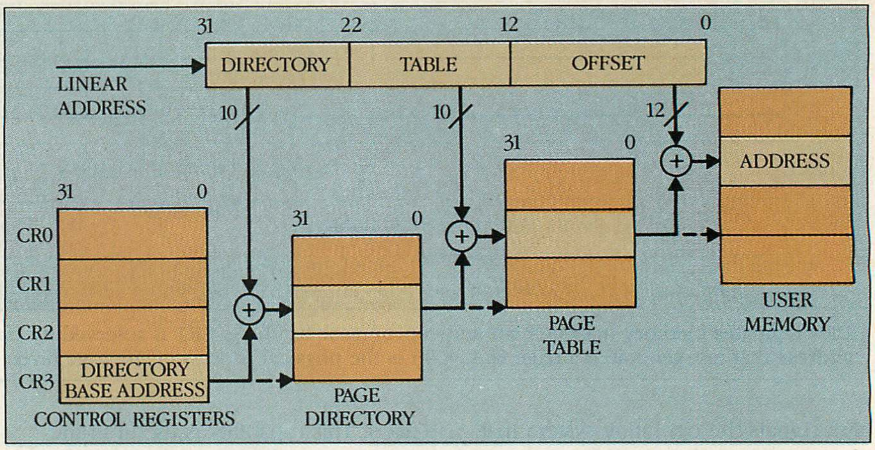
When 80386 descriptors are initialized for use by programs developed for the 80386, the additional capabilities of protected mode can be enabled to create a 32-bit programming environment. Full 32-bit applications (using 32-bit operands and addresses) can execute without instruction prefixes, as is the case in real mode. In addition, the 32-bit programming environment provides data segments of 4GB maximum size by selecting the page granularity in the corresponding descriptors.

Combined, the 16-bit compatibility features and additional functions of 80386 protected mode make it ideal for multitasking operating systems supporting a variety of programming environments. An operating system can provide a virtual memory multitasking environment capable of concurrently executing 16- and 32-bit protected mode applications. The nature of each application (16- or 32-bit) is determined by the configuration of its segment descriptors.

FULL FAMILY COMPATIBILITY

When combined with virtual-8086 mode (an extension of protected mode), the 80386 provides compatibility with applications developed for the 8086/88 while

FIGURE 8: *80386 Memory Paging Mechanism*



Adapted from Intel 80386 Data Sheet

A two-level scheme is used to access a page. In a linear address, bits 22–31 act as an index into the page directory, selecting a page table. Bits 12–21 index into the selected page table to designate the page. Bits 0–11 give the offset into the 4,096-byte page. A page cache is used to avoid this look-up for commonly used pages.

simultaneously providing a full, 32-bit, large linear address programming environment in its protected mode. With this capability an operating system can provide a multiplicity of programming environments that span those in the entire Intel microprocessor family. This family compatibility makes virtual-8086 mode one of the most significant advances of the 80386. (*Virtual* in this context refers to a technique whereby an entire processor environment, or *machine*, is transparently simulated; the term should not be confused with virtual memory techniques used in demand-paged operating systems.)

Virtual environments have historically been used as bridges to provide upward compatibility with existing applications while offering a new environment with enhanced functions and performance. An example of this concept is IBM's virtual machine (VM) operating system architecture for its mainframe systems. VM allows existing applications to be used for production work while new applications that take full advantage of the features of the new machines are being developed.

Virtual-8086 mode allows virtualization of only a real mode environment. Applications for the 8086/88 can execute transparently in virtual-8086 mode under control of a protected mode operating system. These applications perceive that they are running in real mode while actually executing in virtual-8086 mode. Virtual-8086 mode, however, does not provide for execution of 80286 or 80386 protected mode software under supervision of a higher-level program—no level exists that is logically higher in privilege than 0. The 80386 does not allow a protected mode operating system to execute under the control of another like system.

Technically, virtual-8086 mode is a subset of protected mode and is enabled by setting the VM bit in the flags register (see figure 3). In a multitasking, protected mode operating system, virtual-8086 mode is enabled when an 8086/88 application is executed. The primary difference between virtual-8086 and protected modes is in the interpretation of the segment registers. In virtual-8086 mode, the normal protected mode segmentation unit is bypassed and the linear address is calculated as it is in real mode—the segment register value is shifted left by 4 bits and added to the offset. Although the 32-bit addressing modes are allowed in virtual-8086 mode (by use of instruction prefixes), segments are still limited to 64KB, limiting the value of 32-bit addressing. The 64KB limitation also means that virtual-8086 mode addressing is confined to the same 1MB physical address of the 8086/88.

Applications that are designed for the 8086/88 execute transparently in virtual-8086 mode. The main difference between execution in virtual-8086 and real modes is that in virtual-8086 mode all interrupts are vectored through the protected mode interrupt descriptor table (IDT). When a hardware, software, or processor trap interrupt occurs, the IDT entry for that interrupt, typically an interrupt or task gate initialized by the protected mode operating system, causes the VM bit to be reset. The interrupt handler, executing in protected mode, can either take care of the interrupt itself or reflect the interrupt back

PROGRAMMING CONSIDERATIONS FOR THE INTEL FAMILY

In general, software developed for one member of the Intel microprocessor family executes without modification on the others. However, when a software product is under development, the developer should follow a few rules to ensure the product's upward compatibility and its migration to the higher-performance members of the family. Some generally accepted guidelines are listed here.

- A program that is intended to run on all Intel processors should be written to the least common denominator, the 8086/88.
- Any use, implicit or explicit, of the values of registers, flags, or data structures that are declared undefined or reserved in the Intel documentation should be avoided. For example, a program that uses the reserved fields of an 80286 descriptor most likely will not run on an 80386. The multiply (MUL) instruction provides another example; the state of the zero flag is listed as undefined following the execution of MUL. A program that depends on the state of the zero flag after MUL is executed on one member of the family may behave differently when run on another member.
- A program should not depend on the power-on state of processor registers. The value of the various registers and flags after reset is different on the different processors. The program should explicitly load the required register values.
- Instruction opcodes that are not explicitly documented in the Intel literature should not be used. An opcode that is not part of the supported instruction set for a particular processor may be defined differently in a later processor, even if the opcode appeared to have a function in the earlier processor.
- An application should not contain self-modifying code. Due to the difference in prefetch queue length for the various processors, an instruction modification sequence that works correctly on one processor may not modify the target instruction until after it has been prefetched on a different processor. In this case, the unmodified instruction would be executed rather then the modified instruction.
- Because of increases in clock speed and optimizations in the architecture, the 80286 and 80386 tend to execute specific code sequences significantly faster than the 8086/88. In addition, systems based on the same processor may run at different clock speeds. Any code that interacts with realtime events or depends on its execution time to perform its function should use a timing source that is independent of the processor clock speed. Execution-speed-independent timing services are typically provided by the operating system and/or a hardware timer.
- Each peripheral chip or controller in a system has a minimum I/O recovery time—that is, the time required by that peripheral between successive I/O cycles. If a peripheral was designed for operation in an 8086/88 system, this minimum I/O recovery time may be violated when the peripheral is used in the pipelined bus architecture of an 80286- or 80386-based system. In general, 8086/88 I/O speed can be simulated by inserting a JMP $+2 instruction between successive I/O cycles to the same peripheral.
- Routines for the 80286 and 80386 should not be sensitive to the state of the PE bit in the machine status word. Although the 80386 virtual-8086 mode runs with real-mode semantics, it executes with the PE bit set in the machine status word indicating protected mode. The visibility of the PE bit via the store machine status word (SMSW) instruction may cause problems for dual-mode code—that is, code that attempts to act differently based on whether the processor is executing in real or protected mode.

Most of these guidelines are based on common sense; nonetheless, many applications violate one or more of them and therefore fail on one of the Intel processors. One reason may be that the application has been debugged and tested on one processor before another processor is available. In all cases, the appropriate Intel literature should be consulted.

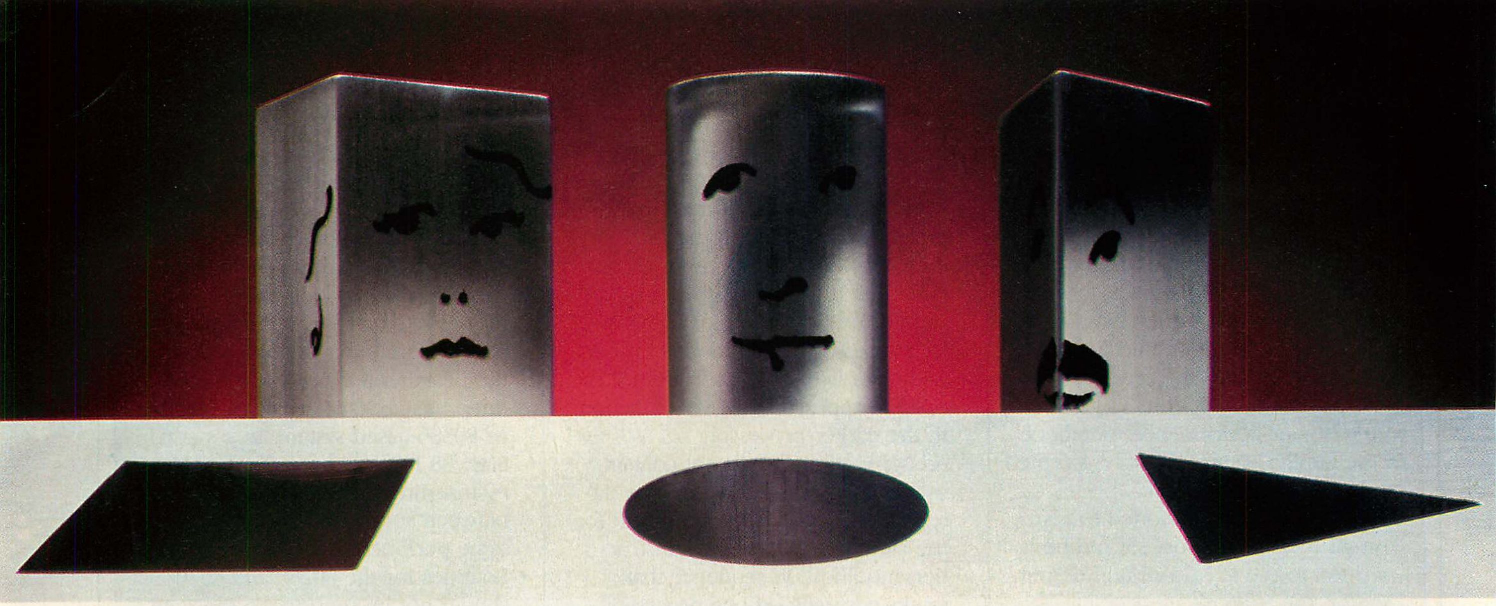
—Caldwell Crosswy and Mike Perez

to the code that normally would have been invoked in the 8086/88 application. This reflection is accomplished by retrieving the appropriate target address from the 8086-equivalent interrupt vectors (the table of 4-byte vectors starting at virtual address 00000000), manipulating the stack frame to contain the address of the 8086/88 interrupt handler, and returning to virtual-8086 mode. The interception and reflection of interrupts is one of the basic functions of a protected mode operating system supervising the execution of an 8086/88 application in virtual-8086 mode.

The other differences between virtual-8086 and real modes involve privileged instructions, IOPL sensitivity, and I/O permission. The ability to control the use of privileged instructions and access to I/O devices in virtual-8086 mode allows the operating system to maintain concurrency between 8086 and protected mode applications.

Privileged instructions cause a general protection fault if executed at a privilege level other than 0. Because code executes at privilege level 3 in virtual-8086 mode (real mode implicitly executes at level 0), these instructions trap to the operating system, which executes at level 0. Load machine status word (LMSW) and load global descriptor table (LGDT) are examples of privileged instructions. Execution of these instructions typically indicates a program's intent to enter protected mode. An application that executes these instructions is usually aborted by the operating system because protected mode applications are not allowed to execute in virtual-8086 mode.

Sensitive instructions are those whose operation is affected by the current IOPL. Again because virtual-8086 mode code runs at privilege level 3, the 2-bit IOPL field in the flags register (figure 3) must be set to 3 to avoid traps on these instructions. The sensitive instructions in virtual-8086 mode are software interrupt (INT), interrupt return (IRET), and push and pop flags (PUSHF/POPF). Though INT is IOPL-sensitive in both protected and virtual-8086 modes, PUSHF, POPF, and IRET are sensitive only in virtual-8086 mode. This allows the operating system to keep track of and virtualize the interrupt flag. For example, an 8086/88 application can attempt to disable hardware interrupts with the clear interrupt flag (CLI) instruction. The operating system can make interrupts appear disabled to the application and continue to handle hardware interrupts necessary for operating system administrative functions



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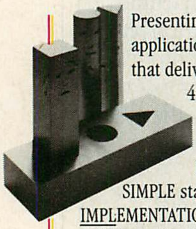

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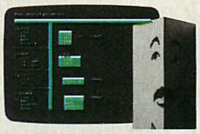

Company Managers like Tom easily develop customized applications like this Branch Reporting System which reports information from support service calls. Tom now has a system which validates certain information and provides a customer history to improve the branch's support capabilities. With SIMPLE's Specify Worksheet on screen, Tom simply joins data from four different files and establishes their relationship.

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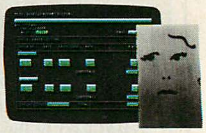

System Analysts/Programmers like Harriett easily prototype design changes while interacting with Department Heads. Harriett has prototyped some requested changes in a Mainframe Payables System. With the help of SIMPLE, she has built a test database with data imported from the mainframe and is able to review the check-ledger report, in the Controller's office on her portable computer.

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MAKING THE MOST OF THE 80386 TODAY

Although operating systems that fully support the features of the 80386 may not be available today, the programmer can take advantage of many 80386 features in real-mode programs now.

- Many instructions such as the immediate forms of ADD and SUBtract have been optimized by directly decreasing the number of cycles required for execution. Others such as MULtiply execute in fewer average cycles due to internal algorithm optimizations. Nothing special is required of the programmer to invoke these improvements; they are built into the 80386 architecture.
- The operand size prefix (66H) can be used to achieve 32-bit data operations. This allows the programmer to take advantage of the extended 32-bit register set for 32-bit arithmetic and logic operations. For example, DB 66H / ADD AX,BX is equivalent to ADD EAX,EBX. The operand size prefix also can be used to speed data manipulations by taking advantage of the full 32-bit width of the 80386 internal and external data paths. One of the most dramatic improvements to existing code can be realized by the use of a 32-bit repeated string move instruction (REP MOVS) in block move operations.
- Two additional segment registers, FS and GS, are available along with the instructions needed to manipulate them. No explanation of the desirability of extra segment registers is necessary to anyone who has programmed the Intel family.
- The new double-shift instructions, SHLD/SHRD, allow the manipulation of full-width (32-bit) bit strings within a double-width (64-bit) bit space. This allows the efficient implementation of such graphics primitives as BITBLT. Because the maximum shift entity on the 8086/88 and the 80286 has been 16 bits, routines such as BITBLT have typically been limited to 8-bit manipulations.
- A full set of conditional jumps with 16-bit displacements is provided. This eliminates the awkward instruction sequence often required (jumping around a jump) when the destination of a conditional jump is more than 127 bytes away.
- The move with sign-extension (MOVSX) and move with zero-extension (MOVZX) instructions allow small operands to be moved into larger ones in a single instruction with automatic size conversion. The high-order part of the destination is filled with the high bit of the source or zeroes. These may be most useful in manipulating the 32-bit register set, but they also allow functions such as MOVZX DI,AL to be done in a single instruction.
- A complete set of single-bit instructions alleviates the time-consuming masking and test-and-set/reset operations that characterize many operating system primitives, such as manipulating the bits in a task's status word. Having a single-instruction implementation assures the indivisible execution of these functions, freeing the programmer from the overhead of framing the operation with the typical CLI/STI.
- The byte set on condition instructions set the destination operand to 0 or 1 depending on the setting of the specified condition flag. This is a useful function for high-level language interfaces that pass status information in registers or memory rather than in the CPU flags. These instructions provide direct translation from CPU status to a byte register or memory operand.
- Although addressing is limited by real-mode semantics to 64KB segments and a 1MB address space, the address size prefix (67H) allows the use of the extended addressing modes of the 80386 in real mode. When the address size prefix is used, any register can be used as base and index registers, with or without the scaling options. The coding of the Mod R/M byte is different in this case, making manual encoding difficult.
- A single-precision uncharacterized multiply instruction complements the immediate form of IMUL that was added to the 80286, but removes the implicit register characterization; therefore, the destination operand can be specified as something other than the AX register.
- New debug registers allow the implementation of a software debugger with hardware debugging capabilities. The debug registers can be programmed to cause a trap when a specific memory location is read or written or when an instruction is executed at that address. This capability previously required external breakpoint hardware.

Selective use of these features can result in applications that achieve high performance relative to the 8086/88 and 80286. It may be desirable, however, for the same application to execute on all members of the Intel family. One approach is to optimize portions of an application that benefit most from the features of the 80386. These optimized portions would be executed only when the application is run on an 80386-based system.

—Caldwell Crosswy and Mike Perez

(such as system timers) and other concurrent protected mode applications.

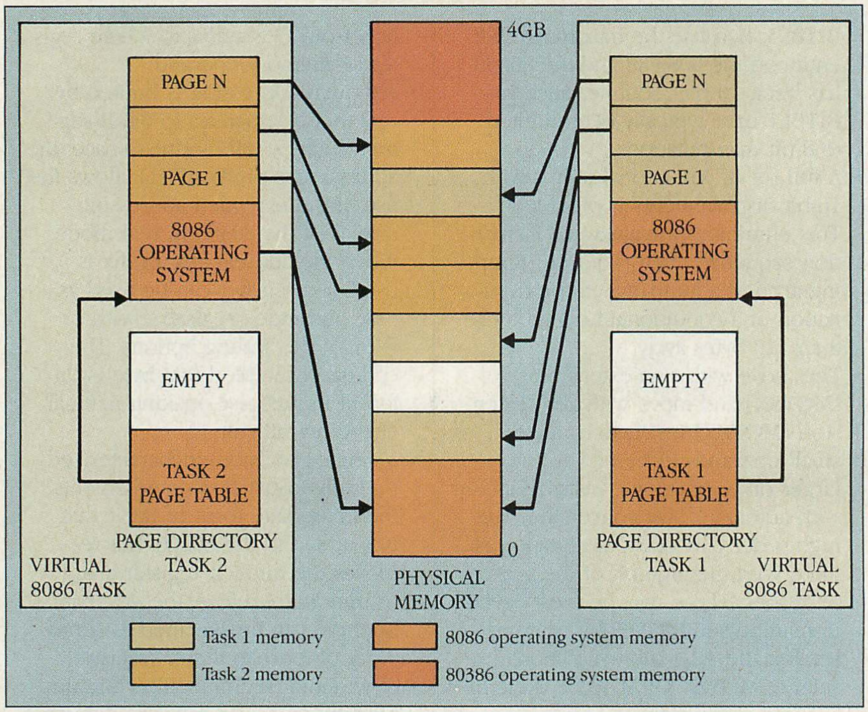
The I/O permission facility allows the operating system to control selected I/O ports. The operating system can set up an I/O permission bit map in the TSS corresponding to the virtual-8086 mode application. The bit map can define specific I/O ports as protected. Any IN or OUT instructions that refer to a protected I/O port will trap to the operating system, which can either emulate or directly execute the instruction.

In all these cases, the operating system decides whether or not a particular instruction will appear to be executed. This action is totally transparent to the program running in virtual-8086 mode—as far as the program is concerned, an emulated instruction appears to have been executed by the 80386 microprocessor. The only potential difference is that simulated instructions or operations may take longer to execute.

Through the use of the 80386's paged memory management features, an operating system can allow more than one 8086/88 machine to be simulated at a time, thus permitting multiple 8086/88 applications to coexist with each other as well as with 32-bit applications. This capability would typically be used in concert with hardware simulation so that each application would see an entire machine, complete with the simulated, peripheral hardware.

To simulate the programming environment of one or more 8086/88 machines, the operating system would provide support for interrupt handling and for the instruction and I/O emulation just as outlined above. In the case of a single, virtual-8086 environment, memory paging would not be enabled and the single virtual-8086 machine would

FIGURE 9: *Virtual-8086 Mode Memory Management*



Adapted from *Intel 80386 Data Sheet*

The paging mechanism gives each virtual-8086 task a 1MB linear address space. Read-only areas, such as the 8086 operating system, can reside on shared pages used by all virtual-8086 tasks. Unused pages can be omitted from physical memory.

INTEL REFERENCES

For further reference, the following literature can be obtained from the Intel Corporation by calling this toll-free number: 800/548-4725.

PROCESSOR	TITLE	ORDER NUMBER	PRICE
8086/88	*The iAPX 88 Book*	210200	$20.95
80286	*Introduction to the iAPX 286*	210308	No charge
	iAPX 286 Programmer's Reference	210498	20.95
	iAPX 286 Hardware Reference	210760	20.95
	iAPX 286 Operating System Writer's Guide	121960	50.00
80386	*Introduction to the 80386* (including the 80386 Data Sheet)	231746	No charge
	80386 Programmer's Reference	230985	25.00
	80386 Hardware Reference	231732	25.00
	80386 System Software Writer's Guide	231499	$23.00
	80386 Data Sheet	231630	No charge

execute in the first physical megabyte of memory, just as it would in real mode. The operating system would normally reside in memory past the first (physical) megabyte or in reserved and/or protected memory within the first megabyte of memory. If multiple 8086/88 machine simulations are desired, or if it is necessary to execute a single 8086/88 machine in a physical location other than the first megabyte, then the paging mechanism must be enabled.

Because the segmentation unit is bypassed in virtual-8086 mode, the paging unit is the only memory management method available to virtual-8086 mode programs. The paging mechanism allows the 1MB address space of virtual-8086 mode to be simulated anywhere in physical memory. Via memory paging the 1MB contiguous memory space of virtual-8086 mode can be created from up to 256 physical memory pages (1MB address space / 4KB per page). Each of these pages can be located anywhere within the 4GB physical address space of the 80386 and need not be physically contiguous, allowing great flexibility.

Using the 80386 memory paging functions, a demand-paged operating system can manage memory for multiple virtual-8086 mode machine simulations concurrently with protected mode applications. Memory paging also can be used to allow each 8086/88 machine simulation to have access to common routines and data, such as a system ROM, by making the physical ROM appear in the memory space of each simulated machine. Actually, only one ROM exists, but each machine sees it at the expected address within its 1MB address space. Figure 9 shows how the 80386 paging mechanism enables multiple virtual-8086 machines to be managed; a single copy of the 8086/88 operating system is made to appear in the address space of both machines.

VIRTUAL PERFORMANCE

The performance of applications executed in virtual-8086 mode is typically lower than in real mode in the same processor, because an operating system is intervening to handle interrupts and emulate certain instructions. The trap operation alone usually takes significantly longer to execute than the instruction that caused it. To this is added the execution time of the code that saves and restores machine state and emulates the instruction. Fortunately, the instructions that must be emulated are relatively few in number and frequency of occurrence. The primary impact is in interrupt-intensive programs, because straight code tends to execute unimpeded in virtual-8086 mode.

Like the instructions themselves, simulated hardware should not be expected to have the same performance as the actual hardware. Differences in performance depend upon the device used. Performance is also affected when simulating more than one 8086/88 machine at a time.

The 80386 provides unprecedented compatibility with previous members of the Intel family while providing the advanced functions required for the development of sophisticated virtual memory operating systems in which 8086/88 applications can coexist with 16- and 32-bit protected mode applications. Even without such advanced operating system software, it is possible to take advantage of the 80386 by using its new instructions and 32-bit data manipulations. Future software advances will unlock the full power of the 80386.

Caldwell Crosswy is a senior systems engineer, and Mike Perez is a systems engineering manager with Compaq Computer Corp.

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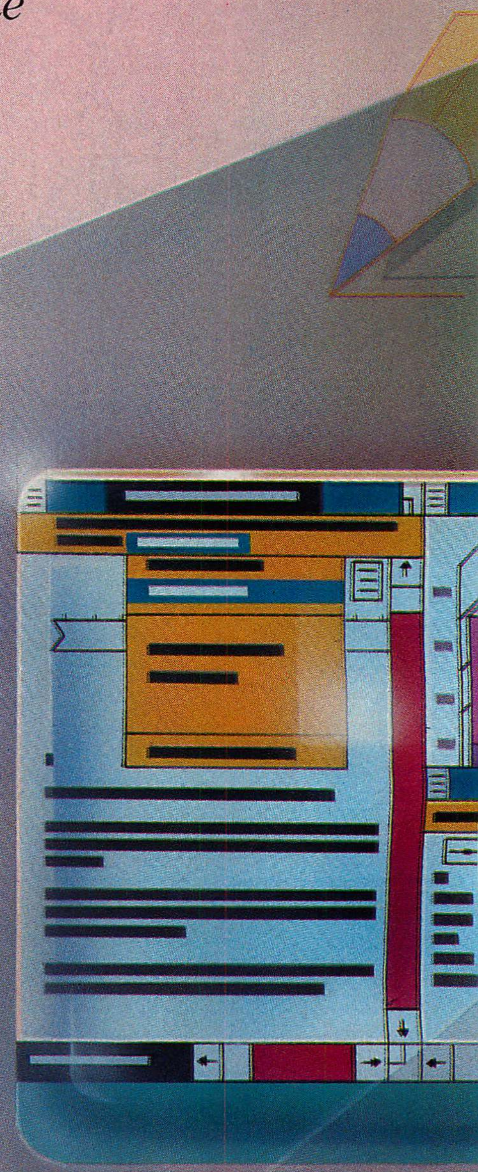
Windows of Opportunity

Microsoft Windows provides a usable, flexible environment for application development. An examination of the Development Kit and a sample application demonstrate the great promise this product holds.

PAUL GRAYSON



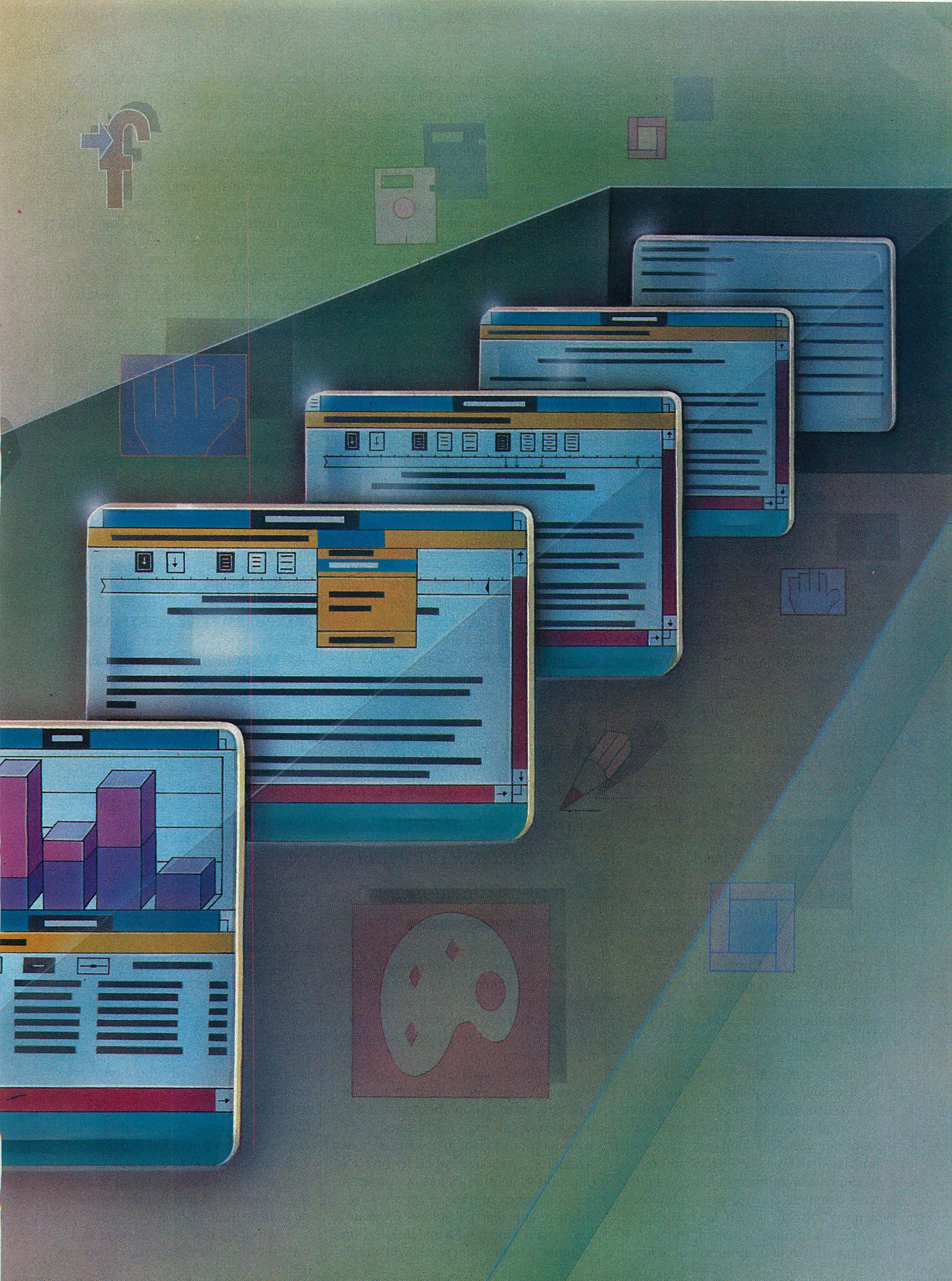
Microsoft Windows may be the most significant microcomputer software development product of the decade. It promises to free users and developers from device dependencies, make programs easier to use, and provide a compatibility bridge to future hardware and software.

Windows is an extension to DOS that adds multitasking, memory management, and additional operating system functionality. As its name implies, users interact with applications via a visual interface—a *window*—several of which can be displayed on the screen at the same time provided the user is running well-behaved standard applications or others developed specifically for Windows.

Putting another layer of operating software between programs and the hardware on which they run has an impact on performance. The more advanced the system, however, the less the impact of the additional layer. Windows must be run on a PC/AT or compatible, or at least a PC/XT with an accelerator board, in order to be useful. A Windows application such as Windows Draw will run on a dual-diskette PC with 320KB, but most users will find it unacceptably slow. The addition of a hard-disk drive or an expanded-memory board will make such a product usable, but more advanced hardware is necessary to truly benefit from Windows.

Developers of applications for Windows have no choice but to use high-performance hardware. A typical Windows

ILLUSTRATION • ANDY LEVINE



development machine consists of an AT with a 20MB hard disk and 2MB of expanded memory. Following is a complete list of system requirements:

- An XT, AT, or compatible that supports Microsoft Windows
- 512KB of memory
- Diskette drive configured as drive A:
- Hard-disk drive configured as drive C: (or second diskette drive that is configured as drive B:)
- Graphics monitor
- IBM Color Graphics Adapter (CGA), IBM Enhanced Graphics Adapter (EGA), or Hercules-compatible graphics adapter
- Mouse (although recommended, one is not required)
- Additional monochrome monitor with display adapter or an external console connected to a serial port (for use as an aid in debugging)

Practically speaking, the more memory and disk space and the faster the processor, the bigger the payoff in reduced compilation times and greater programmer productivity. Consider a typical program compilation that takes 30 minutes on a 6-MHz AT: the same compilation takes only 10 minutes on a Compaq Deskpro 386. While 80286-based machines certainly are acceptable for Windows application development, 80386 machines improve performance significantly over that of ATs.

Developing for Windows also requires DOS 2.1 or later, Microsoft Windows 1.03, the Microsoft Windows Software Development Kit, a development language with bindings for Windows, and a program or text editor. Only Microsoft C 4.0, Pascal 3.3 or later, and Macro Assembler (MASM) 4.0 currently have the necessary runtime libraries to support Windows.

Before writing the source code for a Windows program, a developer must understand the Windows processing model and how it differs from the standard DOS model. Current DOS-based applications take control of the computer when invoked and return control to DOS when they request services from DOS and when they terminate. Even terminate-and-stay-resident applications assume control when started by the user and relinquish it when the user returns to the primary application.

Windows, on the other hand, uses cooperative multitasking and shares available hardware resources among programs executing simultaneously. It takes complete control of a computer's memory, display screen, keyboard, mouse, and timer, managing them among all running applications. Windows, not the application program, is in control. Windows differs from DOS in that it provides improved memory management, nonpreemptive multitasking, a graphics device interface, dynamic data exchange, and clipboard data transfer.

In some respects, Windows functions in a manner analogous to an online, realtime, mainframe transaction processing environment such as IBM's CICS (Customer Information Control System). CICS applications and Windows applications share many processing concepts, foremost among them is reentrant programming.

Program reentrance allows multiple copies of the same program to be executed simultaneously by the operating environment without interfering with each other or with other applications currently running on the same processor. Reentrant programs must not modify themselves as they execute and must place all user-specific variables in a separate and distinct data segment.

In an environment such as CICS, multiple users on different terminals may be executing the same transactions at once. For example, hundreds of bank tellers may be processing demand deposit account (DDA) transactions at the same time. All users are served by a single copy of the application; however, a separate data segment is reserved for each. Windows is similar, yet different.

A typical Windows development machine would consist of an IBM PC/AT with a 20MB hard-disk drive and 2MB of expanded memory.

A single Windows user may be executing multiple copies of the same program, called *instances*, at the same time—such as two instances of the DOS executive being used to view two directories simultaneously.

Windows manages *events* and issues *messages*. An event is an input or a programmed action about which a Windows application might need to know: a mouse click in a window, a key stroke, or a message issued by one application to another. Windows programs are collections of message-processing subprograms. Each Windows program has a main function (WinMain) and one or more window functions. WinMain is the executive that controls the execution of the applications, determines how input should be processed, and directs the execution of the application's window functions, which are application-specific processing functions. A window function processes any messages relayed to it by WinMain, displays and maintains any windows that belong to it, and provides for interaction with other windows and applications.

Windows places a message in an application queue whenever special actions need to be taken that affect a window belonging to that application. The queue belongs to an individual application and is arranged on an FIFO (first-in/first-out) basis. The main function of an application retrieves the message from the queue and sends it to the appropriate window function.

Each message-processing subprogram in a Windows program can be thought of as a stand-alone program designed to process a specific message. Many messages are common to all Windows programs and must have certain like sections, while others are unique and thus require unique code.

NONPREEMPTIVE MULTITASKING

Windows uses a nonpreemptive scheduler to manage multiple tasks. Because such a scheduler is cooperative, each application must "yield" to Windows in order to allow other applications access to the main processor. Windows switches among applications when an application asks for its messages. Once an application has received a message it can execute for as long as it wants; Windows does not issue interrupts to force an application to yield. Windows applications should check frequently for messages in order to yield control and allow other applications to run.

A preemptive multitasking system, such as that found on an IBM mainframe, uses system interrupts to suspend the processing of an application and to allow other operating system functions or applications to be executed. Some preemptive multitaskers use time slicing to allocate the main processor to applications. Each application is given slices of time in which to execute, depending on priorities established by the system operators. Each application continues to execute until it needs the system to perform some service such as I/O (in some systems its execution may be interrupted to allow the execution of higher-priority tasks) or until its time slice completes.

Windows does multitasking with only those applications that are specifi-

cally written for it. While non-Windows applications such as Lotus 1-2-3 or MicroPro's WordStar will run under Windows, they will not do multitasking. When a non-Windows application is started, all currently active Windows applications are suspended.

Windows multitasking is particularly useful for background tasks such as communications and print spooling; a user can execute Windows applications at the same time that a file is being transmitted or received across a communications network or that a large job is being printed.

MEMORY MANAGEMENT

Windows memory management provides two significant features that are not offered in current versions of DOS: dynamic loading and discarding of code and data segments, and insulation of programs from hardware-specific memory architectures.

Code segments within a Windows application can be defined as *fixed* or *movable* through the module definition file (.DEF). The definition file for a sample Windows application is shown in listing 1 (THERME.DEF). All code segments should be defined as movable so that Windows has maximum flexibility in organizing memory. Code segments also may be loaded into memory during initial start-up of the application, or they may be loaded dynamically by Windows. When they are not currently in use, code and data segments also may be discarded dynamically by Windows if memory is scarce.

When an application attempts to allocate more memory than is available, Windows attempts to satisfy the request by dynamically discarding memory until a block of the requested size can be made available. If sufficient memory cannot be obtained, Windows returns error code 0001 to the application.

Normally, Windows manages memory in a way that is transparent to the user. However, if a scarce memory situation occurs and Windows is unable to free enough memory, a degradation in performance occurs. *Thrashing* takes place if Windows begins discarding and loading the same code segments repeatedly. For example, if an application is performing a repetitive operation (such as drawing a series of rectangles) and memory is scarce, Windows may perform an operation, discard the code required to perform that operation during memory compaction, then reload the code segment just discarded.

While performance degradation is more desirable than an application failure, it is of little consolation to a user who must either accept inadequate performance or close down other applications until enough memory is freed to return performance to acceptable levels.

Windows memory management further insulates application programs from hardware-specific memory architectures by using 16-bit "handles" (address pointers) to reference all data variables. Because Windows dynamically allocates and frees memory, compacting it as required, the physical address of a data variable can be changed by Windows. As long as an application always uses a handle to access data, it does not matter where Windows locates that physical data item in memory.

Windows provides two memory pools for use during program execution: the global heap and the local heap. The former is all system memory not allocated to Windows or applications; the latter is free memory in the application's data segment. The maximum size of any local heap is 64KB. Applications obtain memory by using the GlobalAlloc command (for addresses outside of the current 64KB memory segment) and LocalAlloc (for addresses within the current 64KB memory segment). Windows gives the requesting application a handle to the requested memory. The GlobalLock and LocalLock functions are used to lock global and local handles, respectively, before assigning values to the specified memory locations. This prevents the memory object associated with the handles from moving while in use.

Device independence, one of the greatest benefits of Windows, is achieved by applications through the use of a graphics device interface.

Applications are responsible for freeing allocated global memory before they terminate. Windows automatically frees any local memory that has been allocated during execution.

GRAPHICS DEVICE INTERFACE

One of the greatest benefits that Windows provides to application developers and users alike is device independence, which is achieved by Windows applications through the use of a graphics device interface (GDI). Application developers benefit from the GDI because it defines a logical device to which the application sends output. The physical device used, whether display screen, plotter, or matrix printer, is not important to the application because all application I/O is performed to and from logical devices. The same I/O routines are used by an application regardless of the physical device being used; thus, they must be written only once. Translations between the logical device used by Windows and physical devices are performed by device drivers.

In order to maintain device independence, this interface draws images in an internal, logical coordinate system that is mapped to the actual physical coordinate system of the display device. The logical coordinate system has x and y axes, an origin at the center, and coordinate values that range from −32,768 to 32,767.

To draw an image on a device, an application uses a GDI output function to draw in a rectangular area of the logical coordinate system called (in an unfortunate choice of terms) a *window*. GDI then maps the image to the designated device view port, which is simply the rectangular area on the display device that contains the image mapped from the logical coordinate system window. The functions SetWindowOrg and SetWindowExt define the origin and extent (size) of the window in the logical coordinate system. SetViewportOrg and SetViewportExt perform the same function for the device view port. The point (*0,0*) in the physical device coordinate system is always the upper left corner of the view port.

Every device has a logical size in which arbitrary width and height (in inches) are assigned. Usually different from the physical width and height, the logical size is used by applications when writing text or drawing graphics.

For example, the logical screen size of the CGA (640 by 200 pixels) is 6.5 by 4 inches. The pixels per logical inch in the x and y directions are 96 and 48, respectively. The logical screen size of the EGA (640 by 350 pixels) is 6.5 by 5 inches. Its pixels per logical inch are 96 and 72, respectively.

The location of points in an actual image depends upon the transformation equations used to map it from the logical to the physical coordinate system. An application can use SetMapMode to select one of eight different mapping modes that define the orientation of the device's x and y axes and specify scale factors for transforming logical units

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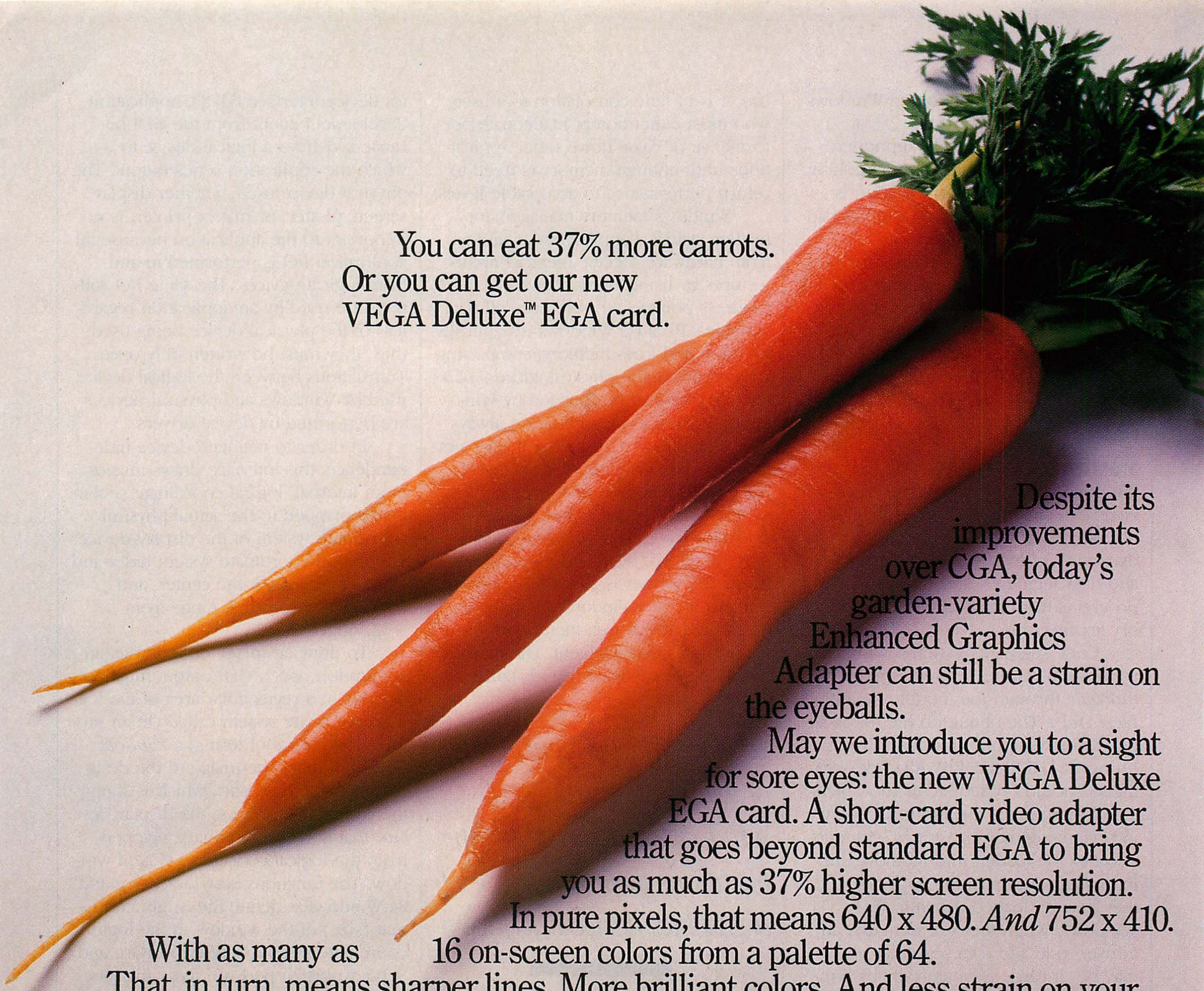

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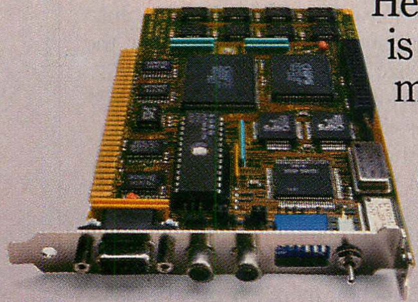

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into device units. The mapping modes are as follows: TEXT, LOMETRIC, HIMETRIC, LOENGLISH, HIENGLISH, TWIPS, ISOTROPIC, and ANISOTROPIC.

These modes fall into three classifications: unconstrained, partially constrained, and completely constrained. The TEXT, LOMETRIC, HIMETRIC, LOENGLISH, HIENGLISH, and TWIPS modes are completely constrained. In these mapping modes, calls to SetWindowExt and SetViewportExt are ignored. Constrained map modes produce nondistorted images in fixed physical units such as pixels, inches, or points, and they provide a way to ensure that a 1-by-1 unit square in logical coordinates is mapped to a 1-by-1 unit square in physical coordinates.

In ISOTROPIC (the partially constrained) mode, window and view-port extents determine scaling and orientation; GDI assures that x and y units are the same. Thus, squares in logical units come out as squares on the device. In the unconstrained (ANISOTROPIC) mode, arbitrary units and scaling may be achieved by setting window and view-port extents to any desired values. This mode does not change the extents, rather it directs the GDI to set an internal flag to indicate that the extents can be arbitrarily changed by using SetWindowExt and SetViewportExt.

A device context, or DC, describes a graphics device and driver. A DC is a data structure in an application's memory that contains all information necessary to create visual output in that applications window. This information includes background and text colors and conventions for combining them, as well as transformations used to map images from the logical coordinate system to the physical device. The DC contains the data itself or handles that point to the data. An application must request, using the CreateDC routine, that Windows create a DC for its window.

The application can update the information in the DC by selecting objects into the DC, setting the mapping mode, setting the clipping region, and so on. Once the application has all of the necessary information contained in the DC, it can perform graphics operations that affect its own window.

The availability of Windows applications and GDI enables equipment manufacturers to make new hardware compatible with an existing base of software simply by writing device drivers for Windows. It is also easier to upgrade hardware (and the Windows device driver) to support new features, higher resolution, and faster modes.

The time that an application developer saves by not developing unique device support can be significant. Certain applications, especially those that make extensive use of graphics, benefit the most. The 40 to 50 percent of programming time spent developing device support in a device-independent environment could instead be directed to improving the application or developing new applications altogether.

Device independence is also important to end users because it protects their investment in software. Users can be confident that drivers will be available for popular devices, and because Windows applications are device independent, upgrades from the software manufacturer to support a new device are not necessary.

Communications between a realtime server and a client Windows application is accomplished through the Dynamic Data Exchange.

Several examples of Windows and Windows-compatible devices are already in use. Video 7's new VEGA Deluxe EGA-compatible graphics adapter supports all the old CGA and EGA standards and offers two new resolution modes—752 by 410 pixels and 640 by 480 pixels—with 16 colors. Few companies offer such features. The VEGA Deluxe comes with a Windows driver that gives Windows applications instant compatibility with these modes.

Quadram's as yet unnamed high-resolution graphics board uses an Intel 82786 graphics coprocessor to achieve a resolution of 640 by 480 pixels with 256 simultaneous colors (from a palette of 1.6 million). This board should be available (with a Windows driver) in the first quarter 1987. The 82786 enables this board to achieve a tenfold increase in graphics performance.

NEC's new color version of the P5 printer is capable of 360-dpi (dots per inch) resolution with unlimited colors. It also should be available (with a Windows driver) in first quarter 1987.

DYNAMIC DATA EXCHANGE

Windows allows intertask communication and the efficient sharing of data among applications. The Windows Dynamic Data Exchange (DDE) protocol is a set of guidelines that allows applications to share data freely using either one-time data transfers or establishing on-going communications in which applications send updates to one another as new data become available.

Intertask communications, the means by which Windows applications receive all input, occur in Windows through messages. Applications may define private messages with unique meanings. The DDE protocol defines some new messages for communications among the applications that use it. Windows also provides for the sharing of data among applications. The DDE protocol uses shared memory as the means for transferring data between applications. The DDE defines some structures to be used in order to pass data.

In any interaction between DDE applications, the application generating the shared data is called the *server* and the application accepting the shared data is the *client*. A DDE link between applications is called a *hot link*.

Communications between an on-line, realtime server and a client Windows application is possible with the DDE. Microsoft has demonstrated an example of this with Lotus Signal and a sample Windows application specifically developed to demonstrate the DDE. Lotus Signal uses an FM sideband receiver to obtain financial data from the New York Stock Exchange. A server was developed to transfer data from Signal into a shared memory area within Windows. As data come over the FM channel, the shared memory area is updated automatically. The client application was coded to detect when the data in this shared memory area changed and to update a spreadsheet and redraw a graph to reflect the new data.

The *clipboard* is another data exchange feature of Windows. It is a pool of handles, accessible to any Windows application, through which applications can exchange formatted data.

Windows applications that follow Microsoft's Style Guide all provide the standard clipboard operations of Cut, Copy, and Paste. Cut deletes selected data from an application and places it in the clipboard; Copy makes a copy of the selected data without deleting it and then places the copy in the clipboard; Paste is used by the receiving application to transfer data from the clipboard into an application.

From a user's point of view, the clipboard holds only one piece of data at a time. Previous data are cleared out every time a new Cut or Copy opera-

tion is performed. Internally, the clipboard holds any number of different data formats and corresponding data handles, all representing the same data but in as many different formats as the application is willing to supply.

For example, if a Windows Draw user selects a portion of a drawing (perhaps a piece of clip art) and copies it to the clipboard, Windows Draw renders three different formats to the clipboard. These formats are bit map, metafile, and Micrografx picture.

[Editor's note: The author is president of Micrografx, developers of the picture format referred to here. A Micrografx picture is decomposable and can record view-port transformations. Specifications for the format are available free from Micrografx; also, they can be obtained from General Electric's GENIE Information Service.—*WF]*

An application receiving the data from the clipboard could choose whatever format that it supported. For example, Windows Paint can transfer only in bit maps while Windows Write can input a metafile or a bit map. Windows Draw can (currently) input only a Micrografx picture.

Bit maps are simply pixel blocks well suited to pixel editors or paint programs such as Windows Paint. However, some limitations are imposed. Bit maps are not easily scaled and lose resolution when they are scaled; in addition, bit maps in Windows are done only in black and white, so any color information is lost during the transfer. Finally, Windows limits the size of bit maps to 64KB maximum.

Metafiles provide a more orderly mechanism for passing pictures among applications. Unlike bit maps, they can pass color information and metafiles can be scaled without loss of resolution. However, metafiles carry their own limitations: they cannot be decomposed, so a receiving application cannot break a metafile picture down into its component symbols (lines, curves, fill patterns). Neither can Metafiles record view-port transformations, which some applications use for scaling pictures.

TABLE 1: *Windows Software Development Kit Contents*

WINDOWS DEVELOPMENT UTILITIES	
EXEHDR.EXE	Displays Windows application file header
IMPLIB.EXE	Creates linkable library files for user-defined, dynamic Windows libraries
LIB.EXE	Creates and maintains library (.LIB) files
LINK4.EXE	Creates executable Windows applications
MAKE.EXE	Performs automatic file maintenance
MAPSYM.EXE	Creates symbol files for symbolic debugging
RC.EXE	Compiles and adds resources to an application
RCCP.EXE	Preprocesses resource script files
SYMDEB.EXE	Symbolic debugger for Windows applications
WINSTUB.EXE	Program to display a message indicating that an application must be run using Windows
WINDOWS DEVELOPMENT APPLICATIONS	
ATRM1111.FNT	Sample font file
DIALOG.EXE	Dialog box editor
FILELIST.TXT	Listing of files in Development Kit
FONTEDIT.EXE	Font editor
HEAPWALK.EXE	Displays lists of owners and sizes of allocated memory blocks in global heap
ICONEDIT.EXE	Creates and edits icons, cursors, and bitmaps
INSTALL.BAT	Batch file used to install Development Kit
MKDEBUG.BAT	Batch file used to create a debugging version of Windows
README.DOC	Installation instructions for Development Kit
SHAKER.EXE	Randomly allocates memory in the global heap
LIBRARIES AND INCLUDE FILES (C language)	
STYLE.H	Windows style definitions for edit control, dialog and list boxes, scroll bars
WINDOWS.H	Windows include file for C applications
LIBW.LIB[a]	Standard Windows library
WINLIBC.LIB[a]	Start-up library for Windows libraries
LIBRARIES AND INCLUDE FILES (Pascal)	
103PATCH.BAT	Patches debugging version Windows KERNEL.EXE to allow support of Pascal applications
CMACROS.INC	Include file for macro assembler macros
PASCAL.LIB	Pascal library for Windows applications
PASLIBW.LIB	Windows library for applications in the Pascal language
WINDOWS.INC	Windows include file for Pascal applications

[a]These file names are prefixed with a C, L, M or S, according to the memory model size: compact, large, medium, or small, respectively.

THE DEVELOPMENT KIT

The Microsoft Windows Development Kit (version 1.03) is required for developing Windows-compatible applications. The kit is a collection of the utilities, debugging aids, and sample source programs necessary to this operation; table 1 lists its contents.

Installing the kit is fairly straightforward once the proper documentation for version 1.03 is located in the README file on the second of two utilities disks. (This file is not mentioned in the printed documentation or the more than 30 pages of updates to it. The documentation updates are not replacement pages, rather they are more than 100 separate items grouped together with section and page-number references.) The README file describes the use of the batch file that will install all of the toolkit except the sample application source files. The printed documentation provides recommended directory names and locations for storing these source files, but the user must consult a file on the second utilities disk to locate particular source files on the toolkit diskettes. To set up the operating environment, the AUTOEXEC.BAT file must be modified using the DOS SET command to assign values to several environment variables. The variables and their meanings are as follows:

LIB	Location of library files used by the development linker (called Link4)
INCLUDE	Location of include files used by compiler
TMP	Location of compiler temporary file directory
TEMP	Location of Windows temporary file directory
PATH	Used by DOS to locate executable files

It may be necessary to expand the environment to accommodate these variables. (See "Environment Expansion," Jim Vallino, November 1986, p. 49.)

Because some of the development utilities are Windows applications, Win-

SYMBOL AND DEBUG FILES	
GDI.EXE	Debugging executable file for GDI library
GDI.SYM	Symbolic debugging file for GDI functions
KERNEL.EXE	Debugging executable file for kernel library
KERNEL.SYM	Symbolic debugging file for kernel functions
USER.EXE	Debugging executable file for user library
USER.SYM	Symbolic debugging file for user functions
SAMPLE APPLICATIONS SOURCE FILES	
CARDFILE	Application similar to the Windows card file
CLOCK	Uses bitmaps and compatible device contexts
FONTTEST	Font and dialog box creation and use
HELLO	General form of a Windows application
MAPMODES	Use of various mapping modes
MOTION	Creation and use of dynamic-link libraries
MUZZLE	General form of a Windows application (Pascal)
SAMPLE	Similar to TEMPLATE but also uses standard file and edit menus and dialog boxes
SHAPES	Shows how to use menus and draw shapes
TEMPLATE	Skeleton application
TRACK	Use of mouse input and visual feedback
TYPE	Keyboard input processing
WINDOWS DEVELOPMENT KIT MANUALS	
Update to Programmer's Reference and Programming Guide	
Describes new features of Windows version 1.03; contains updates and corrections to *Windows Programmer's Reference* and *Windows Programming Guide*	
Microsoft Windows Programmer's Utility Guide	
Describes purpose and use of Development Kit Utilities	
The Microsoft Windows Quick Reference	
Provides a quick reference to Windows functions and messages	
The Microsoft Windows Programming Guide	
Guide to creating Windows applications	
The Microsoft Windows Application Style Guide	
Design guidelines for applications' user interface	
The Microsoft Windows Programmer's Reference	
Describes functions, data types and structures, files, and assembly language macros used by Windows applications	

The Windows Software Development Kit is a collection of utilities, debugging aids, and sample source programs required to develop Windows applications.

dows must be installed on the computer being used for developing applications, and it is also needed to debug Windows applications.

An executable version of Windows is created using the Microsoft Windows Setup program. Setup uses files from the Windows disks to make a version of Windows that is tailored to the specific hardware being used.

Instructions for installing a debugging version of Windows are provided in the README file. The process described includes using the MKDEBUG batch file to copy debugging versions of KERNEL.EXE, USER.EXE, and GDI.EXE (all supplied with the toolkit) to copies of the Windows Setup and Build diskettes. These diskettes are then used to install a debugging version of Windows, which is needed for development purposes. When used with the symbolic debugger in the development toolkit, the debugging version provides comprehensive application debugging support using an external display. A standard version is required only for use of Windows without debugging support.

APPLICATION RESOURCES

A Windows program is made up of source code and resources. Applications can be written in Microsoft C or Pascal, or assembly language. Resources such as icons, cursors, menus, and dialog box templates are created using the Icon and Dialog editors.

The sample application THERME illustrates the Windows application development process. THERME uses an icon, pull-down menus, and a dialog box to create a drawing of a thermometer and output it to the screen or printer. The user can select Fahrenheit and Celsius/Centigrade readings by selecting a "radio" button and can specify the temperature using a scrollable list. Photo 1 shows the THERME display with the print option selected.

To create new Windows programs, these steps must be taken:

- Create cursors, icons, or brushes using IconEdit, the icon editor.
- Create a resource script file containing descriptions of menus or dialog boxes to be used by the application using a text editor and Dialog, the dialog editor.
- Use the Windows resource compiler (RC) to compile application resources and then to copy those resources to the executable file.
- Use a text editor to generate the application's C, Pascal, or assembly language source files.
- Use the appropriate Microsoft compiler to compile the application's source files.
- Use a text editor to create a module definition file.
- Use the linker (Link4) to link the compiled application source files with the Windows libraries and the module definition file.

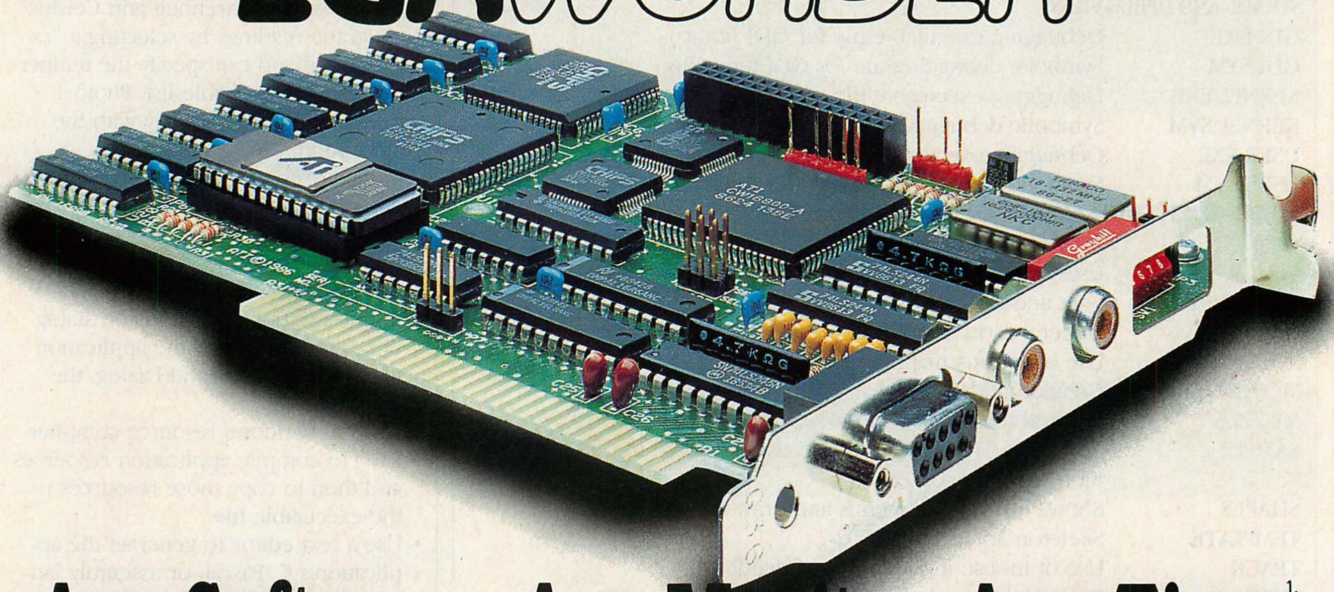
Windows applications typically use a number of resources, such as icons, cursors, fonts, menus, and dialog box templates. These resources must be created, then defined in a resource script file. The resource script file consists of one or more resource statements that identify the resource name and type. The resource script file used by the THERME sample application is shown in listing 2 (THERME.RC).

The ICON key word is followed by the name of the file that contains the icon. The file THERME.ICO was generated using the Icon Editor program (IconEdit), a Windows application used to create customized icons, cursors, and bit maps for the applications. IconEdit lets the user create and edit a large-scale image of an icon, cursor, or bit map while simultaneously viewing it at normal size. A mouse or similar pointing device is required for use with IconEdit. The IconEdit display of the THERME.ICO icon shown in photo 2.

The DIALOG statements and their associated CONTROL statements define the dialog boxes used in THERME. Dialog boxes can be designed in the display screen using the dialog editor.

Because Dialog does not create the other components of a resource file, a

EGAWONDER™



Any Software. Any Monitor. Any Time.[1]

EGA Monitor

EGA Software **Hercules Software**

CGA Software **132 Column Software**

EGA Wonder runs EGA, CGA, MDA, Hercules and 132 Columns on an Enhanced Graphics Display. CGA text is improved to 8 x 14 and graphics are double scanned for a high quality display.

TTL Monochrome Monitor and Compaq PC Portable[2]

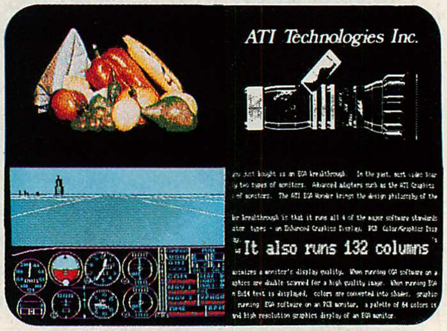
EGA Software **Hercules Software**

CGA Software **132 Column Software**

EGA Wonder runs EGA, CGA, MDA, Hercules and 132 Columns on a TTL Monochrome Monitor and Compaq PC Portable[2]. Colors of EGA and CGA are converted into shades, graphics are full screen and no pre-boot drivers are required.

RGB, Composite Monitors, and the IBM Portable PC

EGA Software **Hercules Software**



CGA Software **132 Column Software**

EGA Wonder also runs EGA, CGA, MDA, Hercules and 132 Columns on an RGB Monitor, Composite Monitor, and the IBM Portable PC in 64 colors (shades). EGA and Hercules software are interlaced for high resolution text and graphics.[3]

Composite monitor and PC Portable display not shown.

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Automatic Switching Between EGA and CGA Color Modes and Among EGA, MDA, and Hercules Modes	✓	✓	
Runs EGA, CGA, MDA, Hercules and 132 Columns on an EGA Monitor	✓		
Runs EGA, CGA, MDA, Hercules and 132 Columns on an RGB Color Monitor	✓		
Runs EGA, CGA, MDA, Hercules and 132 Columns on a TTL Monochrome Monitor	✓		
Runs EGA, CGA, MDA, Hercules and 132 Columns on a Composite Monitor	✓		
Runs EGA, CGA, MDA, Hercules and 132 Columns on an IBM Portable P.C.	✓		
Warranty	2 Yrs	1 Yr	1 Yr
Suggested List Price	$399	$595	$599

*Trademarks: Paradise Auto Switch – Paradise Systems Inc; Quad EGA+ is a trademark of Quadram Corp.; Video-7 – Video-7, Incorporated; IBM PC Portable – IBM – International Business Machines. Compaq — Compaq. Inc

1. "Any Software, Any Monitor, Any Time" applies to IBM graphics, standards, monitors, software.
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3. Flickering effect of interlacing reduced with purchase of anti-glare screen filter.

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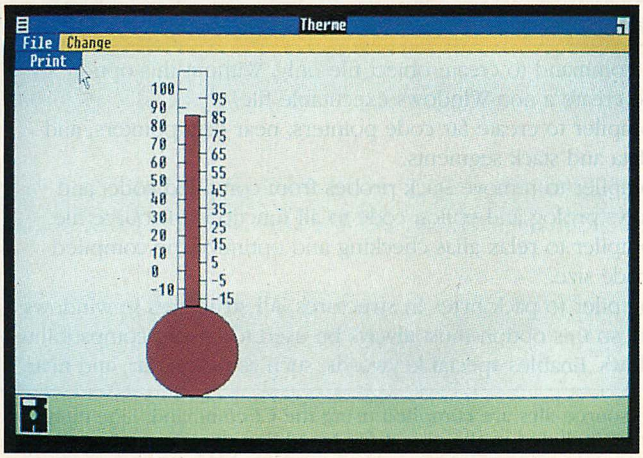
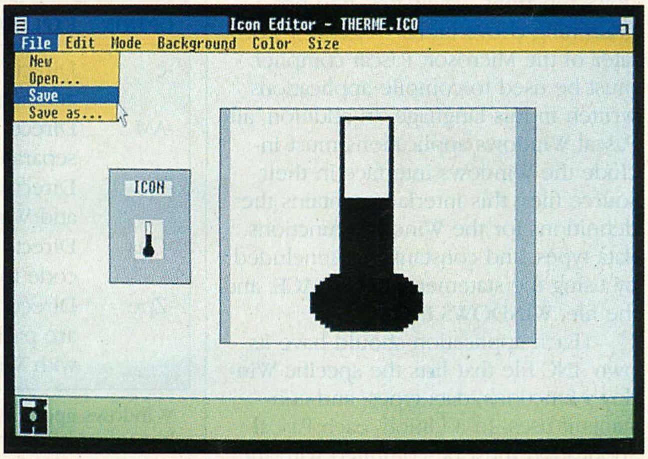
PHOTO 1: *Therme Windows Application*



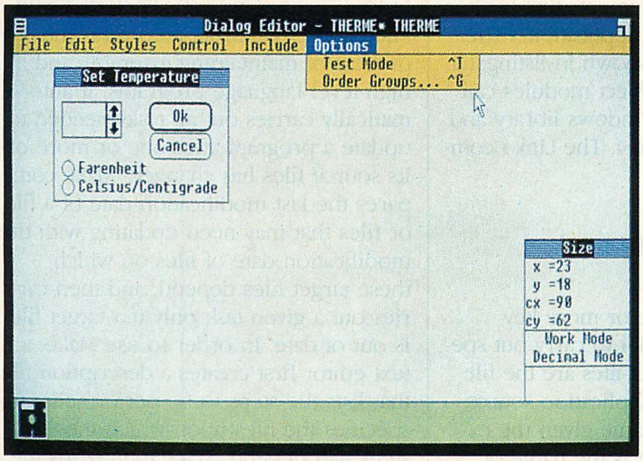
Therme is a C application that accepts keyboard input using a dialog box, then displays and prints a thermometer.

PHOTO 2: *Icon Editor*



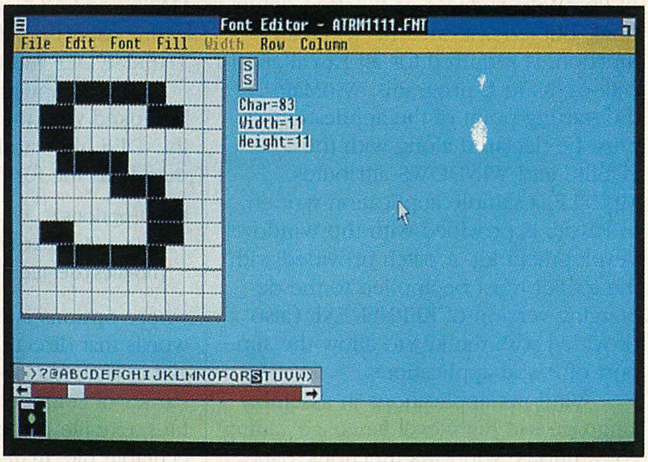
The Icon Editor is used to create customized icons, cursors, and bit maps. A mouse or similar device is required.

PHOTO 3: *Dialog Editor*



The Dialog Editor allows dialog boxes to be designed on the display screen and saved in a resource script file.

PHOTO 4: *Font Editor*



The Font Editor permits the creation of font files for use with applications. A mouse or similar device is required.

.RC (resource script) file defining the other components (icons, menus, bit maps) must be created and complied using RC before Dialog is used).

Dialog is then used to add dialog boxes to the compiled resource (.RES) file. The dialog box that is used in the example resource script file (shown in listing 2) was coded by hand; however, it can be examined and modified using Dialog (see photo 3).

The development kit includes the Font Editor, and although it is not used in the THERME sample application, it is a useful tool that allows the creation of custom font files for use with Windows applications. A font file consists of bit maps of characters used for text display. Font files must be added to a font resource file for them to be used with applications. A mouse or similar device is required to use this editor. Photo 4 shows a sample Font Editor display.

RC also is used to copy the compiled resources to the application's executable file created by linking the application's object modules together with the appropriate Windows libraries. The copy step may be performed at the same time as resource compilation (if the executable file is available), or it may be performed as a separate step.

Shaker and Heapwalker are two utilities provided with the toolkit to aid in application testing. Shaker randomly allocates and frees blocks of global memory to force Windows to move the data and code segments of sample applications. Heapwalker displays information about the size and location of objects in system memory, thus permitting the global heap to be examined.

The Icon Editor, Font Editor, Dialog Editor, Shaker and Heapwalker are all Windows applications, and are started, used, and closed as such.

Each of the three languages in which applications can be developed using Windows has its own requirements. Windows C applications are C programs that use Windows functions, data types, and programming conventions. Listing 3 (THERME.C) is the source code for the sample C application. Programs are compiled using the Microsoft C 4.0 Cl command. Recommended options to use when compiling a Windows program are listed in table 2. The WINDOWS.H file must be included in all C programs. Definitions for all Windows functions, data types, and constants are in WINDOWS.H. The include file, THERME.H (listing 4), declares various data and routines that are used by the main unit.

The starting point for a program is the WinMain function, which handles the creation of windows and reads and dispatches input for the program.

As with C, Pascal Windows applications are Pascal programs that use Windows functions, data types, and programming conventions. Version 3.3 or later of the Microsoft Pascal compiler must be used to compile applications written in this language. In addition, all Pascal Windows applications must include the Windows interface in their source files; this interface contains the definitions for the Windows functions, data types, and constants. It is included by using the statement, INTERFACE, and the file, WINDOWS.INC.

(Each application should have its own .INC file that lists the specific Windows functions, data types, and constants it uses. In addition, each Pascal application must be compiled with the $WINDOWS metacommand.)

Pascal programs must be defined as Pascal modules, not programs. A program module can contain any number of Pascal procedures or function definitions, but at least one, the WinMain function, is required for all Pascal applications. As in C programs, WinMain is the starting point of the application. It must be declared along with the PUBLIC and WINDOWS attributes. MUZZLE, a sample application written in Pascal, is provided with the Windows' development kit. A patch provided with the toolkit must be applied to the debugging version of KERNEL.EXE (also provided with the kit) to allow the support of Pascal applications.

Windows applications in assembly language use high-level language calling conventions, Windows functions, data types, and programming conventions. Microsoft MASM 4.0 must be used to assemble these Windows programs.

Assembly language applications must provide functions that use the same calling and segment conventions as C or Pascal applications. The file CMACROS.INC, included with the development kit, ensures use of these conventions. It defines a set of high-level language macros that can be used in an assembly language source file.

Executable Windows programs are created by linking compiled source files using the Link4 program supplied with the kit. Link4 uses the object modules, a list of Windows and other libraries, and a .DEF file to create an executable file that can load and run under Windows. This .DEF file is a text file containing information about a Windows application: the name, size, format, functions, and segments. Every application must have a .DEF file created before linking.

The .DEF file for an application must contain a NAME statement defining the application's module name. Windows uses this name to identify the application. Most .DEF files also contain DATA and CODE statements that further define aspects of the application. (The THERME.DEF file is shown in listing 1.).

The compiled object modules can be linked with the Windows library and the .DEF file with Link4. The Link4 command has the form

```
Link4[options]
  object-files,[exe-file],[map-file],
  [lib-files],def-file
```

where **options** is one or more key words that direct Link4 to carry out special operations, **object-files** are the file names of compiled application source files, **exe-file** is the name given the executable file, **map-file** is the name of the map file, **lib-files** are the names of Windows or standard language libraries, and **def-file** is the file name of the .DEF file. The commas shown in this command are required to be there.

If an application has more than one object module, all must be named in order to link. This means that more than one **object-file** can be specified if necessary. Multiple file names must be separated by spaces or the plus sign (+). Only one .DEF file is allowed.

To link the application object file THERME.OBJ to the module definition file THERME.DEF and the standard Windows library MLIBW.LIB, the following should be used:

```
link4 therme,therme.exe,therme/map,
  mlibw,therme.def
```

This statement creates the execution file THERME.EXE, which is ready to have resources copied to it using the resource compiler. It also creates the mapping file THERME.MAP, which is used for symbolic debugging.

TABLE 2: *Microsoft C 4.0 Compiler Options*

OPTION	EXPLANATION
-c	Directs Cl command to create object file only. Without this option, Cl attempts to create a non-Windows executable file.
-AM	Directs compiler to create far code pointers, near data pointers, and separate data and stack segments.
-Gsw	Directs compiler to remove stack probes from compiled code, and add Windows prolog and epilog code to all functions in source file.
-Oas	Directs compiler to relax alias checking and optimize the compiled code for code size.
-Zpe	Directs compiler to pack bytes in structures. All structures in windows are packed, so this option must always be used to ensure compatibility with Windows. Enables special keywords, such as **pascal**, **far**, and **near**.

Windows application source files are compiled using the Cl command. Line number information may be included in the object file by adding the -Zd option.

PROGRAM MAINTENANCE

The Windows Software Development kit contains Make, a program maintenance utility. This utility is also included with Microsoft C 4.0. Make automates the process of maintaining assembly and high-level language programs. It automatically carries out all tasks needed to update a program after one or more of its source files has changed. Make compares the last modification date of a file or files that may need updating with the modification date of files on which these target files depend, and then carries out a given task only if a target file is out of date. In order to use Make, a text editor first creates a description file that lists the steps to be performed and specifies the files upon which these steps will depend. Make then reads the description file and performs the requested steps.

A Make description file consists of one or more target-dependent descriptions. Each description is expressed in the following form:

```
targetfile : dependentfiles
command1
[command2]
```

In this statement, **targetfile** is the name of any file that may need updating, **dependentfile** is the name of the file on which the target file depends, and the commands are the names of executable files or DOS internal commands. Listing 5 shows the Make file used to compile and link THERME.

This example defines the steps for creating three target files, each of which has at least one dependent file and one command. The target descriptions are given in the order in which the target files will be created. Thus, the files THERME.OBJ and THERME.RES are examined and created, if necessary, before

THERME.EXE. The window created when THERME.EXE is executed using Windows is shown in photo 1.

WINDOWS DEBUGGING

Microsoft includes a symbolic debugger (SYMDEB) with the Windows Software Development Kit; it is currently the only debugger available for Windows. The CodeView debugger included with Microsoft C version 4.0 does not support Windows software development.

Because Windows takes complete control of the system console, SYMDEB I/O takes place on a separate debugging terminal. The debugging terminal can be an additional monochrome monitor or any ASCII-compatible remote terminal that can be connected to the serial port. When using an additional monochrome monitor, SYMDEB can receive keyboard input before and after the application runs or when it encounters a breakpoint. Using SYMDEB to debug an application involves the following:

- Prepare the symbol files for an application.
- Set up the debugging terminal.
- Start SYMDEB and load Windows along with the symbol files for the application, the Windows USER and GDI libraries, and any other Windows libraries used by the application.
- Interpret SYMDEB allocation messages.
- Display the application's machine and source code.
- Set breakpoints and interpret backtraces.
- Terminate the application and quit SYMDEB.

Symbol files for symbolic debugging are created using **mapsym**, which converts .MAP files into .SYM files that can be used by SYMDEB. The **/map** option is used when linking to create a .MAP file for input to **mapsym**. Line number information can be added to .MAP by adding the **/linenumbers** option when linking, along with the appropriate compiler option to add line numbers to the object file (**-Zd** for C and /l for Pascal). The Windows USER and GDI symbol files, USER.SYM and GDI.SYM, are part of the Kit.

The same methods used to create application symbol files can be used to create symbol files for other Windows libraries. A symbol file for the application is required while symbol files for other Windows libraries are optional but recommended to help trace calls made to routines not in the application or to trace window messages.

SYMDEB options include direction of debugging output to a secondary monochrome monitor, control of the reporting level of memory-allocation messages, loading of SYMDEB macro definitions from a file, and the automatic execution of commands on startup. SYMDEB provides more than 50 debugging commands to allow the user to enable and disable breakpoints, trace and examine object and source code, assemble and disassemble instructions, and examine and change data. SYMDEB I/O can be redirected and commands can be passed to COMMAND.COM.

A BRIDGE TO THE FUTURE

Microsoft was thinking of the future when it developed Windows. It is written in C to make it easily adaptable to various environments. The list of original equipment manufacturers (OEMs) that already have adapted Windows to non-IBM compatible environments includes AT&T, Hewlett-Packard, Digital Equipment Corporation, and Apricot. Considering that a large portion of Microsoft revenue comes from the sale of systems software to OEMs, compatibility with new hardware from OEMs is a rather important issue.

Many of Microsoft's objectives are universal. All software vendors design products to be compatible with as wide a range of hardware as possible. Vendors want to avoid major rewrites of applications whenever changes to the hardware base occur. Only a few software vendors develop device drivers for a profit; most would prefer never to write another.

Microsoft is in a position to address the problems of both software and hardware compatibility, and Windows is its dynamic response.

Microsoft is in a position to address the problems of software and hardware compatibility, and Windows is its dynamic response. Not static, Windows has been updated twice since its release, and rumors concerning new versions of Windows are rife in the industry. Although Windows has some problems, it has many strong points. It provides a standard graphic user interface, memory management, device independence, a well-defined interface for communications between applications, and the promise of compatibility with future hardware and software.

Windows is an adjunct to DOS that provides many useful services that DOS does not. Not surprisingly, the cost for these services is performance. Because of the huge overhead that Windows imposes, an 80286-based microcomputer is required for applications to perform with acceptable response times. In addition, applications cannot effectively share the screen and processor unless they are developed specifically to run with Windows. Developing applications to Windows specifications (as opposed to normal DOS specifications) is more time consuming, the development process itself is much more complex, and the program takes considerable time to learn (as explained in this month's Directions column, "Far Afield with Windows," Will Fastie, p. 9).

The up side of all of this is that Windows acts as an insulating layer between applications and DOS. Therefore, as new versions of DOS are released, Windows applications should be able to run without change. When a version of Windows becomes available to exploit the capabilities of 80386 machines, users of Windows and Windows applications should benefit immediately. Applications *and* Windows will run faster because the 80386 is faster. More to the point, Windows will run at speeds that PC users demand, and the improved architectural features offered by the 80386 machines will allow applications (both Windows-specific and not) to execute in harmony with (and protected from) each other.

Windows provides a usable, flexible environment for application development. It provides workable multitasking and memory management features now, and the promise of future enhanced versions that will continue to support current Windows applications. Windows represents a real opportunity for software developers.

Windows: $99
Application Development Kit: $500
Microsoft C Compiler: $450
Microsoft Pascal Compiler: $300
Microsoft MASM: $150
Microsoft Corporation
16011 Northeast 36th Way
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Redmond, WA 98073-9717
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*Paul Grayson is president of Micrografx, Inc., developers of the drawing programs In*A*Vision and Windows Draw.*

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LISTING 1: THERME.DEF

```
NAME    Therme

DESCRIPTION 'Simple Microsoft Windows Application'

STUB    'WINSTUB.EXE'

CODE    MOVEABLE
DATA    MOVEABLE MULTIPLE

HEAPSIZE  4096
STACKSIZE 4096

SEGMENTS
        _TEXT           PRELOAD     MOVEABLE DISCARDABLE

EXPORTS
      AppWndProc @1
      about_dialog @2
      print_dialog @3
      set_temp_dialog @4
```

LISTING 2: THERME.RC

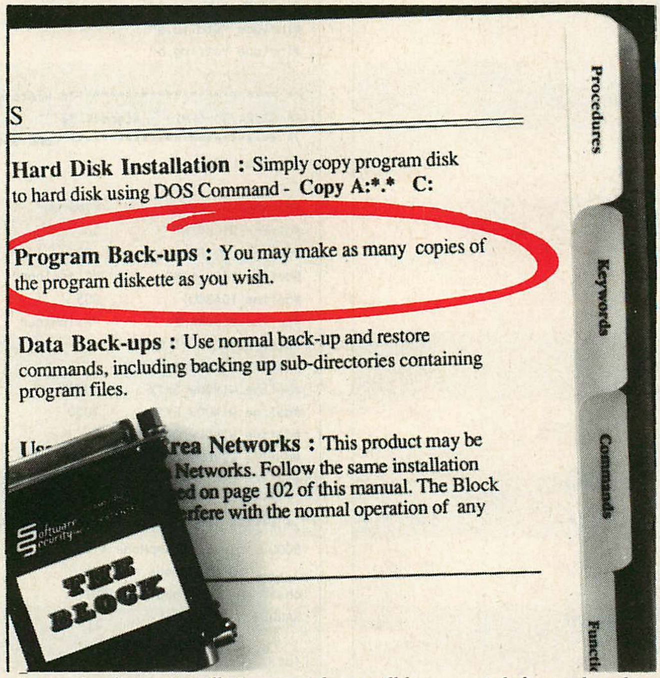
```
#include <windows.h>
#include "therme.h"

ClassIcon  ICON  Therme.Ico

MainMenu MENU

BEGIN
     POPUP "File"
     BEGIN
        MENUITEM "Print", PRINT
     END

     POPUP "Change"
     BEGIN
        MENUITEM "Set Temperature", SET_TEMPERATURE
     END
END

AboutDlg DIALOG 22,17,124,96
   STYLE WS_POPUP | WS_DLGFRAME | WS_VISIBLE
BEGIN
   CONTROL "Sample Windows Application",0,static,SS_LEFT,20,0,104,8
   ICON  "ClassIcon",0,0,0,0,0
   CONTROL "Micrografx, Inc.",0,static,SS_LEFT,20,16,104,8
   CONTROL "1820 N. Greenville Ave.",0,static,SS_LEFT,20,24,104,8
   CONTROL "Richardson TX 75081",0,static,SS_LEFT,20,32,104,8
   CONTROL "Author:  Patrick Leary",0,static,SS_LEFT,20,48,104,8
   DEFPUSHBUTTON "Ok",IDOK,46,72,32,16
END

SetTempDlg DIALOG 22,17,90,62
   STYLE WS_POPUP | WS_DLGFRAME | WS_VISIBLE | WS_CAPTION
   CAPTION "Set Temperature"
BEGIN
   CONTROL "",0,STATIC,SS_BLACKFRAME,4,8,24,20
   CONTROL "",SET_DEGS,STATIC,SS_CENTER,12,12,12,8
   CONTROL "",SCROLL_DEGS,"SCROLLBAR",SBS_VERT | WS_TABSTOP,28,8,8,20
   DEFPUSHBUTTON "Ok",IDOK,50,8,32,16
   PUSHBUTTON "Cancel",IDCANCEL,50,24,32,16
   RADIOBUTTON "Farenheit",FARENHEIT,4,40,50,10,WS_TABSTOP | WS_GROUP
   RADIOBUTTON "Celsius/Centigrade",CELSIUS,4,50,86,10,
END

SpoolDlg DIALOG 50,50,84,40
   CAPTION "Print"
   STYLE WS_CAPTION | WS_POPUPWINDOW | WS_VISIBLE
BEGIN
   CONTROL "Spooling Drawing...",0,STATIC,SS_LEFT,4,8,76,8
   DEFPUSHBUTTON "Cancel",IDCANCEL,29,20,30,15,WS_GROUP | WS_TABSTOP
END
```

LISTING 3: THERME.C

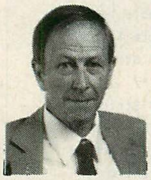
```
/* (c) Copyright 1986 MICROGRAFX, Inc.,
   1820 N. Greenville Ave., Richardson, Tx. 75081.
***************************************************************************
                                THERME.C
***************************************************************************
This Module defines the all routines that control the application.
When the application is loaded, Windows calls the WinMain procedure.
WinMain initializes key variables used by the various functions in the
application and creates a window for it via the initialization
function.  It then waits for input values, passing them to the window
procedure each time an event occurs. */

#include <windows.h>
#include "therme.h"
#include "stdlib.h"
#include "string.h"

/* *************************** History ***************************** */
/* 11/24/86 (PML) - signoff */
/* ************************** Constants **************************** */
#define LOCAL

#define APP_CLASS          "Therme"       /* Window Class Name */
#define HIGHTEMP           100            /* Highest Displayable Temp */
#define LOWTEMP            -20            /* Lowest Displayable Temp */
#define ICON_NAME          "ClassIcon"    /* Resource Icon ID String */
#define IDABOUT            005            /* ID for About... */
#define MENUNAME           "MainMenu"     /* Resource Menu ID String */
#define VIEWPORT_ORGX      0              /* Viewport Origin X Coord */
#define VIEWPORT_ORGY      0              /* Viewport Origin Y Coord */
#define WINDOW_EXTX        1000           /* Window Extent X Coord */
#define WINDOW_EXTY        1000           /* Window Extent Y Coord */
#define WINDOW_ORGX        0              /* Window Origin X Coord */
#define WINDOW_ORGY        0              /* Window Origin Y Coord */
#define WND_NAME           "Therme"       /* Window Name */

/* ************************** Local Data *************************** */
BOOL    bCurrentTempMode = TRUE,          /* TRUE for Farenheit */
        bOldTempMode = TRUE;              /* Previous Temp Mode */
char    ProStringBuffer [80];             /* Profile String Buffer */
HANDLE  hModule,                          /* Instance Handle */
        hWindow;                          /* Window Handle */
int     GraphicTemp = 0,                  /* Graphic Temp Setting */
        DegreeInc = 1,                    /* Temperature Increment */
        OldTemp,                          /* Previous Temp Setting */
        MathTemp;                         /* Math Temp. Conversion */
PAINTSTRUCT Paint;                        /* Window Paint Structure */
RECT    ClientRect;                       /* Client Area Rect. */
WORD    ViewportWidth,                    /* Viewport X Extent */
        ViewportHeight,                   /* Viewport Y Extent */
        ViewportOriginX = 0,              /* Viewport X Extent */
        ViewportOriginY = 0;              /* Viewport Y Extent */

/* ************************ Local Routines ************************* */
LOCAL BOOL NEAR PASCAL command (HWND,WORD);
LOCAL WORD NEAR PASCAL dialog_box (HWND,LPSTR,FARPROC);
LOCAL HWND NEAR PASCAL init_app (HANDLE,HANDLE,LPSTR,int);
LOCAL void NEAR PASCAL paint_window (HDC,WORD,WORD);
LOCAL BOOL NEAR PASCAL show_menu (HANDLE,HWND);

LOCAL BOOL NEAR PASCAL command (hWindow,Choice)
   /* This routine receives and processes menu input. It calls the
      various dialog box functions and initiating the print task */
HWND hWindow;
WORD Choice;
{
          BOOL      bHandled = TRUE;
          BYTE      Item;
          FARPROC   lpPrintProc;
          HANDLE    hPrintDlg;
          HDC       hPrintDC;
          int       PrintResult;
          PSTR      pDriverName,
                    pPortName;
          WORD      HRes,
                    VRes;
```

"How to protect your software by letting people copy it."

By Dick Erett, President of Software Security



Soon all software installation procedures will be as straightforward as this. The only difference will be whether you include the option to steal your product or not.



Inventor and entrepreneur, Dick Erett, explains his company's view on the protection of intellectual property.

"A crucial point that even sophisticated software development companies and the trade press seem to be missing or ignoring is this:

Software protection must be understood to be a distinctively different concept from that commonly referred to as copy protection.

Fundamentally, software protection involves devising a method that prevents unauthorized use of a program, without restricting a legitimate user from making any number of additional copies or preventing program operation via hard disk or LANs.

Logic dictates that magnetic media can no more protect itself from misuse than a padlock can lock itself.

Software protection must reside outside the actual storage media. The technique can then be made as tamper proof as deemed necessary. If one is clever enough, patent law can be brought to bear on the method.

Software protection is at a crossroads and the choices are clear. You can give product away to a segment of the market, or take a stand against the theft of your intellectual property.

"...giving your software away is fine..."

We strongly believe that giving your software away is fine, if you make the decision to do so. However, if the public's sense of ethics is determining company policy, then you are no longer in control.

We have patented a device that protects your software while allowing unlimited archival copies and uninhibited use of hard disks and LANs. The name of this product is The BLOCK™.

The BLOCK is the only patented method we know of to protect your investment. It answers all the complaints of reasonable people concerning software protection.

In reality, the only people who could object are those who would like the option of stealing your company's product.

"...eliminating the rationale for copy-busting..."

Since The BLOCK allows a user to make unlimited archival copies the rationale for copy-busting programs is eliminated.

The BLOCK is fully protected by federal patent law rather than the less effective copyright statutes. The law clearly prohibits the production of work-alike devices to replace The BLOCK.

The BLOCK attaches to any communications port of virtually any microcomputer. It comes with a unique customer product number programmed into the circuit.

The BLOCK is transparent to any device attached to the port. Once it is in place users are essentially unaware of its presence. The BLOCK may be daisy-chained to provide security for more than one software package.

Each software developer devises their own procedure for accessing The BLOCK to confirm a legitimate user. If it is not present, then the program can take appropriate action.

"...possibilities... limited only by your imagination..."

The elegance of The BLOCK lies in its simplicity. Once you understand the principle of The BLOCK, hundreds of possibilities will manifest themselves, limited only by your imagination.

Your efforts, investments and intellectual property belong to you, and you have an obligation to protect them. Let us help you safeguard what's rightfully yours. Call today for our brochure, or a demo unit."

Software Security inc.

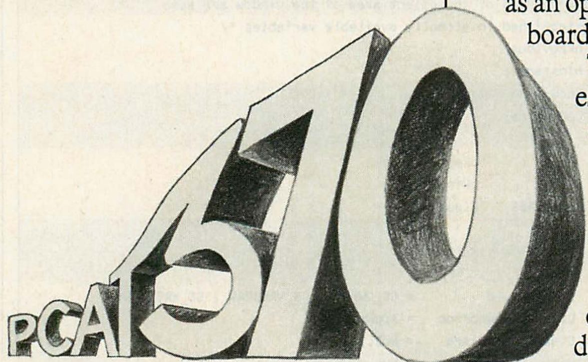
870 High Ridge Road Stamford, Connecticut 06905

203 329 8870

CIRCLE NO. 189 ON READER SERVICE CARD

```
        switch (Choice)
        {
        case IDABOUT:
           dialog_box (hWindow,(LPSTR) "AboutDlg",about_dialog);
           break;

        case SET_TEMPERATURE:
           dialog_box (hWindow,(LPSTR) "SetTempDlg",set_temp_dialog);
           break;

        case PRINT:
           GetProfileString ((LPSTR) "windows",
                             (LPSTR) "device",
                             NULL,
                             (LPSTR) ProStringBuffer,
                             80);
           pDriverName = strchr (ProStringBuffer,',');
           *pDriverName = '\0';
           pDriverName++;
           pPortName = strchr (pDriverName,',');
           *pPortName = '\0';
           pPortName++;
           hPrintDC = CreateDC ((LPSTR) pDriverName,
                                (LPSTR) ProStringBuffer,
                                (LPSTR) pPortName,
                                NULL);
           if (hPrintDC == NULL)
              Item = MessageBox (hWindow,
                        (LPSTR) "Cannot Print. Please Select Printer",
                        (LPSTR) NULL,
                        MB_OK | MB_ICONHAND);
           else
           {
              HRes = GetDeviceCaps (hPrintDC,HORZRES);
              VRes = GetDeviceCaps (hPrintDC,VERTRES);
              lpPrintProc = MakeProcInstance (print_dialog,hModule);
              hPrintDlg = CreateDialog (hModule,(LPSTR) "SpoolDlg",
                                hWindow,lpPrintProc);
              PrintResult = Escape (hPrintDC,STARTDOC,11,
                                (LPSTR) "Thermometer",NULL);
              if (PrintResult == -1)
                 Item = MessageBox (hWindow,
                (LPSTR) "Cannot Print.  Bad Port or Insuffic. Memory",
                                  (LPSTR) NULL,
                                  MB_OK | MB_ICONHAND);
              else
              {
              paint_window (hPrintDC,HRes,VRes);
              Escape (hPrintDC,NEWFRAME,NULL,NULL,NULL);
              Escape (hPrintDC,ENDDOC,NULL,NULL,NULL);
              DestroyWindow (hPrintDlg);
              DeleteDC (hPrintDC);
              FreeProcInstance (lpPrintProc);
              }
           }
           break;

        default:
           bHandled = FALSE;
        }

        return (bHandled);
}
LOCAL WORD NEAR PASCAL dialog_box (hWindow,lpDialog,lpCallBack)
   /* This function displays a given dialog box and returns the value
      ret'd by the dialog box call-back function.  The function first
      creates a relocation-independent version of the call-back
      function, then calls DialogBox. If Windows indicates an
      insufficient memory condition exists, then the user is so
      informed. Additionally, since the drawing area always needs to
      be updated after a dialog box is removed, the client area of the
      window is invalidated so as to be completely redrawn. */
HWND    hWindow;
LPSTR   lpDialog;
FARPROC lpCallBack;
{
        BYTE    Item;
        FARPROC lpProc = MakeProcInstance (lpCallBack,hModule);
        int     Result = DialogBox (hModule,lpDialog,hWindow,lpProc);

        if (Result == -1)
        {
           Item = MessageBox (hWindow,
              (LPSTR) "Not Enough Memory To Display Dialog Box",
                          (LPSTR) NULL,
                          MB_OK | MB_ICONHAND);
        }
        FreeProcInstance (lpProc);
        InvalidateRect (hWindow,(LPRECT) &ClientRect,TRUE);
        return (Result);
}
LOCAL HWND NEAR PASCAL init_app (hPrevious,hInstance,lpCmdLine,Show)
   /* This function handles the initialization of the sample
      application.  This includes registering the window class,
      creating the window, and loading the menus. The viewport
      coordinates of the client area of the window are also
      established in globally available variables */
HANDLE hPrevious,
       hInstance;
int    Show;
LPSTR  lpCmdLine;
{
        BOOL        bRegistered;
        HWND        hWindow;
        WNDCLASS    Class;

        hModule = hInstance;

        Class.style          = CS_OWNDC | CS_VREDRAW | CS_HREDRAW;
        Class.lpfnWndProc    = AppWndProc;
        Class.cbClsExtra     = NULL;
        Class.cbWndExtra     = NULL;
        Class.hInstance      = hInstance;
        Class.hCursor        = LoadCursor(NULL,IDC_ARROW);
        Class.hIcon          = LoadIcon(hInstance,(LPSTR) "ClassIcon");
        Class.hbrBackground = GetStockObject (WHITE_BRUSH);
        Class.lpszMenuName = (LPSTR) NULL;
        Class.lpszClassName = (LPSTR) APP_CLASS;

        bRegistered = RegisterClass((LPWNDCLASS) &Class);

        hWindow = CreateWindow ((LPSTR) APP_CLASS,
                                (LPSTR) WND_NAME,
                                WS_TILEDWINDOW,
                                0,
                                0,
                                0,
                                0,
                                (HWND) NULL,
                                (HMENU) NULL,
                                (HANDLE) hInstance,
                                (LPSTR) NULL);
        ShowWindow (hWindow,Show);

        GetClientRect (hWindow,(LPRECT) &ClientRect);
        ViewportWidth = ClientRect.right;
        ViewportHeight= ClientRect.bottom;

        show_menu (hInstance,hWindow);
        return (hWindow);
}
LOCAL void NEAR PASCAL paint_window (hDC,ExtentX,ExtentY)
   /* This function erases the window background and repaints the
      thermometer using the given device context.  The variable
      GraphicTemp is used to visibly update the rectangle that
      represents the temperature. */
HDC  hDC;
WORD ExtentX,
     ExtentY;
{
        char        Buffer[3];
        int         StartHashX = 460,
                    StartHashY = 100,
                    EndHashX   = 485,
                    EndHashY   = 100,
                    HashCount  = 12,
                    HashInc    = 5,
                    Degree     = HIGHTEMP,
                    StringLength;
        PSTR        pDegreeString;

        SetMapMode (hDC,MM_ISOTROPIC);
```

Alsys launches PC AT-TO-370 ADA Cross-Compiler at November ADA Expo; 80286 Debugger also introduced.



A new Alsys cross-compiler permitting Ada programs to be written on an IBM-PC AT and executed on an IBM 370 was introduced at the November Ada Expo in Charleston, W. VA. The cross-compiler, pre-validated to AJPO test suite 1.7, is priced at $2,995 and includes a 4 MB RAM board.

Two compilers, the Alsys validated PC AT self-hosted compiler, and the AT-to-370 cross-compiler, are offered as an option at $4,995. One RAM board serves both compilers.

The cross-compiler, and especially the two-compiler option, implements a "distributed programming" environment for which the Ada language and its "package" concept is particularly suited. The two-compiler option permits developers to program in Ada and test their results at their workstations before uploading 370 object code to the mainframe.

Alsys also introduced its PC AT debugger called AdaPROBE at the Expo. AdaPROBE combines a unique Ada-VIEWER with regular debug facilities.

ALSYS, INC.,
1432 Main Street, Waltham, MA 02154
PCTJ 2/87
ADA NOW. Tell me more about the cross-compiler.

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Company ____________

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In the UK: Alsys Ltd., Partridge House, Newtown Rd., Henley-on-Thames, Oxon RG9 1EN Tel: 44 (491) 579090

In the rest of the world: Alsys SA, 29, Avenue de Versailles, 78170 La Celle St. Cloud, France Tel: 33 (1) 3918.12.44

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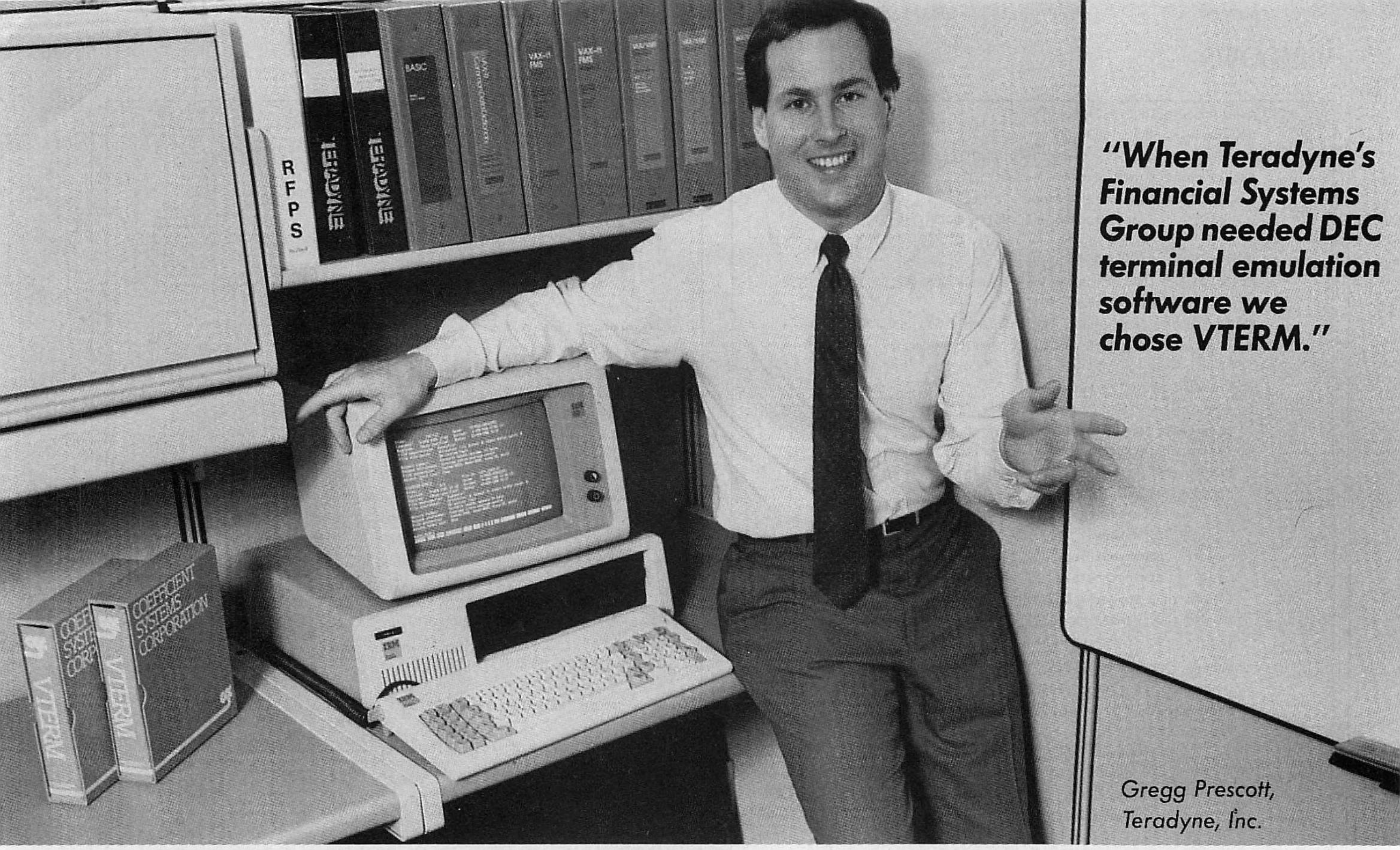
Ada now

```
        SetWindowOrg (hDC,0,0);
        SetWindowExt (hDC,1000,1000);
        SetViewportOrg (hDC,ViewportOriginX,ViewportOriginY);
        SetViewportExt (hDC,ExtentX,ExtentY);
        FillRect (hDC,(LPRECT) &Paint.rcPaint,
                  GetStockObject (WHITE_BRUSH));

        Rectangle (hDC,460,50,540,725);
        SelectObject (hDC,CreateSolidBrush (RGB (255,00,00)));
        Ellipse (hDC,375,700,625,950);
        Rectangle (hDC,480,(600 - (GraphicTemp * 5)),520,700);
        SelectObject (hDC,GetStockObject (WHITE_BRUSH));

        for (;HashCount>=1;--HashCount)
        {
           pDegreeString = itoa (Degree,Buffer,10);
           StringLength = strlen (pDegreeString);
           MoveTo (hDC,StartHashX,StartHashY);
           TextOut (hDC,
                    (StartHashX-75),
                    (StartHashY-15),
                    pDegreeString,
                    StringLength);
           LineTo (hDC,EndHashX,EndHashY);
           MoveTo (hDC,(EndHashX + 30),(EndHashY + 25));
           LineTo (hDC,(EndHashX + 55),(EndHashY + 25));
           Degree = Degree - HashInc;
           pDegreeString = itoa (Degree,Buffer,10);
           StringLength = strlen (pDegreeString);
           TextOut (hDC,
                    (EndHashX + 65),
                    (EndHashY + 10),
                    pDegreeString,
                    StringLength);

           StartHashY = StartHashY + 50;
           EndHashY = EndHashY + 50;
           Degree = Degree - HashInc;
        }
}
LOCAL BOOL NEAR PASCAL show_menu (hInstance,hWindow)
   /* This function loads and displays the available menu resources,
      and adds the "About..." option to the system menu. */
HANDLE hInstance;
HWND   hWindow;
{
        BOOL     bSetMenu;
        HMENU    hMenuResource,
                 hSysMenu;

        hMenuResource = LoadMenu (hInstance,(LPSTR) MENUNAME);
        bSetMenu = SetMenu (hWindow,hMenuResource);
        hSysMenu = GetSystemMenu(hWindow,0);
        ChangeMenu (hSysMenu,NULL,(LPSTR) NULL,NULL,
              MF_SEPARATOR | MF_APPEND);
        ChangeMenu (hSysMenu,IDABOUT,(LPSTR) "About...",IDABOUT,
              MF_APPEND);
        return (bSetMenu);
}
/* ********************** Exported Routines *********************** */
long FAR PASCAL AppWndProc (hWindow,Message,Word,Long)
   /* This Routine handles all input to the application.  Any input
      values that the routine chooses not to handle are passed to the
      default window procedure. */
HWND     hWindow;
unsigned Message;
WORD     Word;
long     Long;
{
        BOOL bHandled = TRUE;
        long Result;

        if (Message == WM_COMMAND || Message == WM_SYSCOMMAND)
              bHandled = command (hWindow,Word);
        else if (Message == WM_PAINT)
        {
           paint_window (BeginPaint (hWindow,(LPPAINTSTRUCT) &Paint),
                         ViewportWidth,
                         ViewportHeight);
           EndPaint (hWindow,(LPPAINTSTRUCT) &Paint);
        }
        else
           bHandled = FALSE;

        if (bHandled == TRUE)
           Result = (long) 0;
        else
           Result = DefWindowProc (hWindow,Message,Word,Long);

        return (Result);
}
BOOL FAR PASCAL about_dialog (hDialog,Message,Word,Long)
HWND hDialog;
unsigned Message;
WORD Word;
LONG Long;
 /* This function is called by Windows to handle input to the About...
    dialog box.  Since "OK" is the only option available to the user,
    only one message is processed, namely, WM_COMMAND. */
{
        BOOL Result = TRUE;

        if (Message == WM_COMMAND)
           EndDialog (hDialog,Result);
        else
           Result = FALSE;

        return (Result);
}
BOOL FAR PASCAL print_dialog (hDialog,Message,Word,Long)
HWND hDialog;
unsigned Message;
WORD Word;
LONG Long;
   /* This function processes input to the modeless dialog box created
      when the user selects the "Print" command from the file menu. */
{
        BOOL Result = TRUE;

        if (Message == WM_COMMAND && Word == IDCANCEL)
           EndDialog (hDialog,Result);
        else
           Result = FALSE;
        return (Result);
}
BOOL FAR PASCAL set_temp_dialog (hDialog,Message,Word,Long)
HWND hDialog;
unsigned Message;
WORD Word;
LONG Long;
   /* This function is called by Windows to process input to the Set
      Temperature dialog box.  It looks for input from the scroll bars
      and updates the associated control each time a WM_VSCROLL
      message is received.  As part of the dialog's initialization,
      the current temperature is remembered in case the user changes
      it and then cancels the dialog.  This ensures that the correct
      temperature will be displayed.  The GraphicTemp variable is used
      for visible updating of the Thermometer when MathTemp falls
      within displayable limits. */
{
        BOOL Result = TRUE;

        if (Message == WM_INITDIALOG)
        {
           SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
           OldTemp = MathTemp;
           bOldTempMode = bCurrentTempMode;
           if (bCurrentTempMode == TRUE)
              CheckRadioButton (hDialog,FARENHEIT,CELSIUS,FARENHEIT);
           else
              CheckRadioButton (hDialog,FARENHEIT,CELSIUS,CELSIUS);
        }
        else if (Message == WM_COMMAND)
        {
           switch (Word)
           {
              case CELSIUS:
                 CheckRadioButton (hDialog,FARENHEIT,CELSIUS,CELSIUS);
                 if (bCurrentTempMode == TRUE)
                 {
```



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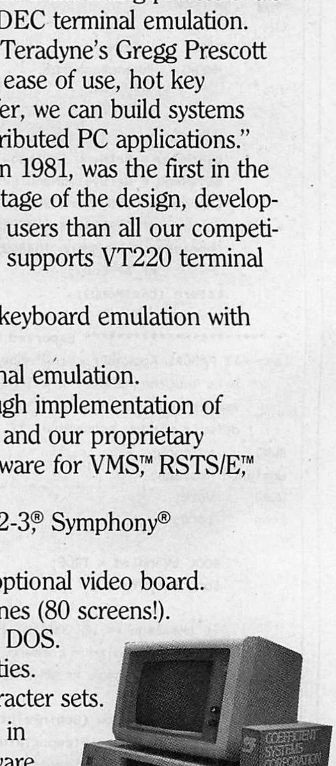

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```
        MathTemp = (5*(MathTemp - 32))/9;
        if (MathTemp > HIGHTEMP)
           GraphicTemp = HIGHTEMP;
        else if (MathTemp < LOWTEMP)
           GraphicTemp = LOWTEMP;
        else
           GraphicTemp = MathTemp;

        bCurrentTempMode = FALSE;
        SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
     }
     else
        break;

     break;

  case FARENHEIT:
     CheckRadioButton (hDialog,FARENHEIT,CELSIUS,FARENHEIT);
     if (bCurrentTempMode == FALSE)
     {
        MathTemp = ((9*MathTemp)/5)+32;
        if (MathTemp > HIGHTEMP)
           GraphicTemp = HIGHTEMP;
        else if (MathTemp < LOWTEMP)
           GraphicTemp = LOWTEMP;
           else
              GraphicTemp = MathTemp;
           bCurrentTempMode = TRUE;
           SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
        }
        else
           break;

        break;

     case IDOK:
        EndDialog (hDialog,Word);
        break;
     case IDCANCEL:
        MathTemp = OldTemp;
        bCurrentTempMode = bOldTempMode;
        EndDialog (hDialog,Word);
        break;
     default:
        ;
  }
}
else if (Message == WM_VSCROLL)
{
  switch (Word)
  {
     case SB_LINEUP:
        MathTemp = MathTemp + DegreeInc;
        break;
     case SB_LINEDOWN:
        MathTemp = MathTemp - DegreeInc;
        break;
     default:
        MathTemp = MathTemp + 0;
  }

  if (MathTemp < LOWTEMP)
  {
     GraphicTemp = LOWTEMP;
     SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
  }
  else if (MathTemp > HIGHTEMP)
  {
     GraphicTemp = HIGHTEMP;
     SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
  }
  else
  {
     GraphicTemp = MathTemp;
     SetDlgItemInt (hDialog,SET_DEGS,MathTemp,1);
  }
}
else
     Result = FALSE;
```

```
        return (Result);
}
int FAR PASCAL WinMain(hInstance,hPrevious,lpCmdLine,Show)
   /* This routine is called whenever a new instance of the
      application is created.  First, init_app is called so that all
      necessary initialization can take place.  Then a loop is created
      that waits for input to the application and dispatches the input
      values to the application's window procedure. */
HANDLE hInstance,
       hPrevious;
LPSTR  lpCmdLine;
int    Show;
{
        HWND hWindow;

        hWindow = init_app (hPrevious,hInstance,lpCmdLine,Show);

        if (hWindow != NULL)
        {
                MSG Message;

                while (GetMessage ((LPMSG) &Message,NULL,0,0))
                {
                        TranslateMessage ((LPMSG) &Message);
                        DispatchMessage ((LPMSG) &Message);
                }
        }
        return (0);
}
```

LISTING 4: THERME.H

```
/* (c) Copyright 1985 MICROGRAFX, Inc.,
   1820 N. Greenville Ave., Richardson, Tx. 75081.

**************************************************************************
                                 THERME.H
**************************************************************************
This file declares data and routines exported by THERME.C.             */

#define CELSIUS          04
#define FARENHEIT        03
#define LINT_ARGS
#define PRINT            100
#define SCROLL_DEGS      02
#define SET_DEGS         01
#define SET_TEMPERATURE  300

extern BOOL FAR PASCAL about_dialog (HWND,unsigned,WORD,long);
extern long FAR PASCAL AppWndProc (HWND,unsigned,WORD,long);
extern BOOL FAR PASCAL print_dialog (HWND,unsigned,WORD,long);
extern BOOL FAR PASCAL set_temp_dialog (HWND,unsigned,WORD,long);
extern int  FAR PASCAL WinMain (HANDLE,HANDLE,LPSTR,int);
```

LISTING 5: THERME

```
therme.obj: therme.c \
   therme.h
      cl -c -AM -Gsw -Oas -Zpe therme.c

therme.res: therme.rc \
   therme.h \
   therme.ico
      rc -r therme.rc

therme.exe: therme.def \
   therme.obj \
   therme.res
      link4 therme,therme.exe,therme/map,mlibw,therme.def
      mapsym therme
      rc therme.res
```

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Similar to the Unix MAKE utility, Pmaker keeps track of which modules in a program are changed, and recompiles, reassembles, and relinks those modules to produce a finished product—all with a single command. An essential tool for managing large, complicated, or distributed programming projects, Pmaker is easier to use than similar products, which require you to create lists of all your input files. Pmaker includes a utility that automatically creates and edits such lists based on answers to a few simple questions. Pmaker works with any compiled language, linker, or other tool you use.
List: **$125** PC Brand: **$105**

Plink™ 86*plus*

Plink86*plus* is the only linkage editor containing advanced overlay capabilities. It handles any compiler or assembler producing standard Intel or Microsoft OBJ files, including COBOL and FORTRAN, Lattice C, CI C-86, Microsoft/IBM languages, and mbp/COBOL. Virtual memory management ensures ample capacity for symbol and common block names (35,000). Plink86*plus* supports an unlimited size file, an unlimited number of modules and up to 4,095 overlays nested up to 32 deep. Merges object modules, caches overlays in extended or expanded memory, and automatically reloads overlays upon function return. Includes Plib86 object library manager.
List: **$495** PC Brand: **$359**

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Plib86 is an object module librarian for Microsoft and Intel format object modules and libraries. With Plib86, you can add, delete or extract modules to or from libraries, and explode a library to its component modules with one command. Plib86 also produces program cross-reference listings in various formats to a disk file, screen or printer.

Originally listed at $195. Plib86 is now included with Plink86*plus*.

Ptel

A Pfantastic communications program for use with most popular modems such as Hayes and compatibles, DEC, Racal Vadic, Anchor, US Robotics and Novation. Ptel automatically adapts to Telink, XModem, Kermit or Modem 7 for CRC checking and for ufn and afn (i.e. "wildcard") file name list transfers, if the bulletin board or the other end computer supports them. With Telink, you'll even get a forecast of file transmission time, always useful in controlling telephone expenses.

In addition to saving received files, Ptel can create and save a transcript of the session commands and messages.

Highly configurable, with choices temporary or saved as altered defaults. Unique telephone directory of bulletin boards and other services, allowing access by service name. Ptel runs fully interactive or can be batch driven from a script. You can even exit to DOS move files around or run another application and then return to Ptel, all without dropping the line.
List: **$195** PC Brand: **$149**

Pasm™ 86

Pasm86 provides both quick assembly and superior syntax checking, plus a wealth of other features and utilities to maximize programming productivity. It is a fully MASM-compatible 8086 macro assembler that supports 8087, 80286 and 80287 operating code mnemonics. Features include ability to: define local symbols in the current procedure, assemble files with up to 15,000 symbols, define symbols at assembly time, obtain listings of error lines only, with warning messages on questionable statements. Pasm's comprehensive documentation includes detailed descriptions and examples of each processor instruction. Now includes Pfix-Lite, a subset of Pfix86*plus*.
List: **$195** PC Brand: **$144**

Pmate™

A full screen, single keystroke, fully customizable text processor/editor with advanced features including: ability to run in the background, C and FORTRAN specific macros, automatic disk buffering, ten individual auxiliary buffers, menu, mouse, or command driven with extensive macro command language, and horizontal scrolling. Pmate offers automatic word wrap, text formatting, global or local setting of margins, tab stops, indents, and a unique last-in, first-out "garbage stack" that saves deleted items for recovery.
List: **$195** PC Brand: **$149**

Pre-C™

Now twice as fast! Similar to the Unix LINT for C, but with additional functionality. It crosschecks multiple source files and libraries at once, reporting incorrect, obsolete, and non-portable C usages that no compiler would catch. Pre-C immediately uncovers errors in interfaces between program modules which are very difficult to find using only a debugger. Pre-C accepts full UNIX System III C syntax, a subset of which is implemented by most MS-DOS C compilers, as well as ANSI proposed extensions. External libraries can be used with or without source code. Pre-C libraries for the latest releases of the Mark Williams, Lattice, CI, Microsoft, Wizard, and Aztec "C" compilers are included, and others can be added by supplying Pre-C with function names and arguments. All memory models are supported.
List: **$295** PC Brand: **$208**

Pfinish™

Pfinish helps to "fine-tune" a software product by identifying inefficient or unnecessary sections of code that need to be rewritten for maximum performance. It analyzes your program during execution, producing reports and histograms that give a snapshot of which routines were reached, their callers, how many times each is executed, how much time is spent in each, how many instructions are executed in each, and more. Histograms and tabular reports, sorted by address or symbol, may be written in any page width or height, to a file, the console, or the printer. Pfinish, unlike other "profilers", can use symbol table information to produce much more meaningful analyses on overlays and interrupts.
List: **$395** PC Brand: **$279**

Pdisk™

Pdisk is a complete disk management package that includes advanced Backup/Restore, Tree Management and Disk Cache utilites. Menu, command line or file-driven. Many options permit backup/restore inclusions/exclusions, whole and partial subdirectories, backups by date/time, file type, and backups of all files or files changedsince last backup. It can also maintain a log of backups. Supports AT high-density floppies, PC floppies, and any storage device accessible through a device driver. Tree-oriented Directory, Delete, Copy, Compare, and Remove-Directory simplify management of complicated subdirectory structures. CACHE significantly speeds up disk operation on PC/XT/AT by keeping data in memory instead of disk. In addition, CACHE is compatible with the Lotus-Intel-Microsoft (LIM) expanded memory specification, as well as extended memory.
List: **$195** PC Brand: **$148**

Pfix™ 86*plus*

Pfix86*plus* is an easy to use, menu driven, multi-windowed symbolic debugger that works with any IBM or Microsoft compiled language. Pfix86*plus* accesses the full symbol table provided by MS Link or Plink86*plus*, and automatically handles Plink86*plus*-overlaid or resident programs. Source code, assembly language translations, stack, data areas, and breakpoints are displayed simultaneously. Features include: In-line assembler for temporary patches, temporary and permanent breakpoint settings, full speed or trace modes, user-assignable variables, dual-monitor support, up to 100-step traceback, debug log to disk or printer, synchronized source file display, breakpoints in source code, disassembly to disk, configurable menus, multiple code and data windows, and keystroke macros.
List: **$395** PC Brand: **$279**

PforCe™

PforCe is a pre-coded optimized object-oriented toolkit of over 400 routines for C programmers. It includes data bases with B-trees, windows, interrupt-driven communications, string handling, menus, all of the basic DOS interfaces, and a complete set of low-level functions to interface directly to the hardware. PforCe comes complete with indexed reference manual, on line resident help, and quick reference card. It supports all memory models of the following C compilers: Lattice, Aztec, Microsoft, CI-86, and Wizard. PforCe includes full source code and there are no royalties on generated applications using the libraries. A demonstration diskette is also available.
List: **$395** PC Brand: **$289**

Pfantasy Pac

A super value pac of Phoenix goodies. Includes Pfix86*plus*, Pmate, Ptel, Plink86*plus*, Pmaker and Pfinish.
List: $1295 PC Brand: $895

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BRIEF *Is Anything But. A Whopper of an Editor*

With a name that belies its thoroughness, Brief™ has every feature you've ever contemplated for your editor-in-chief. Text, from keyboard or files, is housed in multiple buffers, and scrolled through one or more windows you open, close, resize. A text buffer may be called to different windows to view two areas at once. A change in one changes both. Text blocks may be marked for printing, writing to files, movement to scrap buffers for cut and paste into other buffers, or deletion, with as many "undo" levels as you want.

Brief has text search abilities rivaling "grep", with wildcards for matching, indifference to intervening characters, acceptance of character ranges.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own Lisp-like macro language which has structure, 32-character variable names, conditional execution, loops, and you can actually read it! Nothing like the hieroglyphs we've seen elsewhere. Bulletin board and public domain disks with macros. "Simply the best text editor you can buy", Dvorak *Infoworld*. (Needs 192k.)

Ask for:	List:	PC Brand:
U0590	$195	**Call**

HALO GRAPHICS SYSTEM *Multi-Board Graphics Library*

The premier graphics library that got the ball rolling for PC-based graphics and has grown so omnipotent that it supports over 25 graphics boards — including IBM's EGA and Nr. 9 Revolution's hi-res series — and has a multitude of mouse and printer drivers. All that in each box. Separate C versions for Lattice, M'soft, Aztec, C186. What does Multi-Halo do? A down to the last pixel graphics library plus functions to reset drivers so distributed program can run on anything. Wonderful value for single license. Costly royalties though for redistribution. Specify: S0315 & Language. List: **$300.** We: **$219.** With Dr. Halo II, a free-standing "paint": List: **$440,** Us: **$299.**

WINDOWS for C/WINDOWS for DATA *Microsoft Windows™ and TopView™ Compatible*

Windows for C™ is a library of over 80 functions to add the pizazz and practicality of window partitioning to your application. Unlimited windows, each defined in a C structure for easy reference throughout your program, can be made either to pop up or permanently overwrite the screen. Routines will scroll and highlight lists with arrow keys, will read and scroll ASCII files vertically and horizontally in windows, and even write to memory-loaded files off the screen.

Logical treatment of video attributes permits unchanged programs to run on color or monochrome. Colors of windows are set individually.

All functions are in separate modules; only those used are linked. Only buffers holding on-screen or temporarily obscured windows occupy RAM; others released dynamically. Best overall rating and fastest display in Bill Hunt's 7/85 *Tech Journal* review of five windowing products.

Windows for Data comprises all of Windows for C but takes in data through the windows as well. At the high level a single function lets you specify prompt string, field length, data type, screen location, picture, target variable, then sets lesser functions scurrying to get and process a user's input. There are utilities to get system date and time, mess with strings, create your own masks for fields.

Field options can require entry, prevent entry, permit insert or overtype, beeping on invalid or overflow keystrokes, and attachment of field-specific help messages and functions you want called to display messages or validate entries. And you decide which keys will clear a field, jump to the next or prior, quit, etc. Options diverse enough that a set of "fields" can be made to behave like a Lotus™ menu.

Specify Compiler:	List:	PC Brand:
T0100 Windows for C	$195	$149
T0150 Windows for Data	$295	$259

MICROSOFT C 4.0 *A Great C Battle Rages and You're Winning*

As the dreadnaughts pound each other with ever heavier ordnance, today's programmers reap the spoils of this war. Bundling a source debugger and a "make", and sporting a "huge" memory model permitting single data objects larger than 64k, the Microsoft C compiler has jumped a full version number to 4.0. But what's really impressive are the benchmarks reported in Dr. Dobb's (8/86) encyclopaedic survey of 17 C compilers. Microsoft's and IBM's C (licensed from Microsoft) run away with the contest winning 11 of 27 benchmarks.

The CodeView™ debugger, free for a limited time, uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows—use a mouse if you like—obviate learning of commands. "A source-level debugger that puts the rest to shame" (Dobb's).

Microsoft C now has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips. A big plus in multi-language settings: call from this C any routine written in later versions of M'soft Pascal, FORTRAN, or Macro Assembler. Object code of all four may be intermixed come link time or commingled into libraries.

Both linker and library manager are part of the package, as is the "make", a UNIX™ name for a smart batch program which knows to expend minimum effort to rebuild any size of project by compiling and assembling only elements affected by new or changed modules.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

Ask for:	List:	PC Brand:
G0500	$450	$295

C-TREE *B-Tree File Manager, Source Code, No Royalties!*

C-tree is sturdy code that has weathered many seasons of prolonged and widespread use. It comes in C source, so you can modify it to fit a special case. No royalties provided you bind it into your binary application.

C-tree's design splits nodes to allow any number of users to access an index file simultaneously even when updates are in progress. So multi-user configurations and adaptation to networks are possible. Record-locking routines are provided for DOS 3.1/3.2, UNIX and XENIX.

Thanks to source code which does not deviate from the K&R standard, C-tree can travel. Tests in many environments prove that C-tree gives your application a ticket to anywhere.

C-tree permits any number of keys for a data file, supports duplicate keys, alphanumeric or numeric, supports files of variable record length; multiple keys in one index file, and keys of variable length. Both high level ISAM routines which handle details with minimum coding, and decomposed step-by-step functions you can access directly. It's comprehensive.

Ask for:	List:	PC Brand:
F0660	$395	$329

CURSES *Unix Style Screen Management*

Curses from Lattice™ manages the screen of the PC like Unix™ curses. Library of 84 functions and macros parallels Unix with matching parameter lists. So Unix programs are at home on the PC, and vice versa. Keeps any number of screens in memory, supports color, vast function set to get characters, wrap lines, scroll, blank lines, highlight, etc. Like Unix refreshes screen only on your command. Ask for: L0850. List: **$125.** Here: **$99.** With Source: L0860, **$250/$199**

dBC *Lattice Library Maintains dBASE Compatible Files With the Power and Speed of C*

dBC™ links C to dBASE. It creates and maintains files and their indexes which exactly replicate dBASE file design. So dBASE can read and update them. And the reverse. dBC can use any files created by dBASE. Now C and dBASE can operate on the same data bases interchangeably.

That opens up the widespread culture of dBASE installations to exploitation by C programmers. Tap that market, avoid the resident dBASE language, and gain the advantages of C with this single product.

dBC's functions parallel all dBASE's file handling commands, many decomposed to give closer control. Each backed by demo source files on disk.

Use dBC for custom work for clients, or on its own. It's a complete ISAM file manager for C whether or not dBASE will be used in tandem, supports all four memory models, and can have sixteen index and data files open. Big discount to buyers of both dBASE II and III versions. Specify Lattice, Microsoft 3.x, or DeSmet.

Versions:		List:	PC Brand:
L00II	For dBASE II	$250	$195
LCCII	With Source	$500	$390
L0III	For dBASE III	$250	$195
LCIII	With Source	$500	$390

PANEL *Feature-Laden Screen Design Tool*

Writing your own screenware can blow completion dates and profits. Panel™ works with you interactively to set up foolproof screen displays and data entry forms rapidly. Output is C source code.

Not just single plane: layer your screen designs with up to ten overlapping images: Background pop-up lists, help boxes, and alternate input fields.

Panel builds in a user interface for keystroke movement within and between fields, supplies validation routines for checking user field entries. Diverse attributes may be selected for any field — size, data type, color, conversion of input to upper case; clearance of existing data when new entry is started; masks for standard formats (eg, dates); phrases which fill in when their first letter is typed; multiple-choice lists from which to choose by cursoring a highlighted bar. Fields may be multi-lined and scrolled if larger than the screen space allotted them. Specify: S0400 & Compiler. List: **$295,** Us: **$229**

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GREENLEAF FUNCTIONS *Bountiful Harvest*

C source, assembler source, and binary libraries of 225 functions for many compilers. Emphasizes tight functional groupings to minimize loading code which your application may never use. Manual helps select functions, bulletin board, too.

A sampling: *DOS* extensions for file and directory manipulation; *Screen:* to select mode, page, monochrome or color, palette; cursor shape, positioning; clearing and scrolling; pixel get and put; read light pen. *Strings:* Center, justify, etc.; efficient list operations which add, delete, sort string pointers for top speed. *Other:* graphics character primitives, keyboard status, function key assignment, time/date, read registers and memory size, peek and poke. Mature best-seller. Specify: S0770 & Compiler. List: **$185**, Here: **$139**

GREENLEAF COMMUNICATIONS *Hello World*

Want your application to communicate with other users or remote date bases by asynchronous communications built right into your C programs! Even if you don't need it now, that's a skill to have at the ready!

120 functions *and demo programs in both C and assembler source code* set up separate transmit and receive ring buffers for up to 16 simultaneous channels. Interrupt driven so you can halt an incoming record, display it, file it, let the user edit it, then continue. Goodbye separate communications software.

Supports up to 9600 baud, ASCII or binary, any parity or word length, 8250 UARTs, Xon/Xoff and Xmodem, WideTrack receive. Specify: S0750 & Compiler. List: **$185**, Us: **$139**

INTERACTIVE-C

Compiler-Compatible Interpreter, Editor, Debugger

Earlier C interpreters were miraculous compromises. Interactive-C shows how far C interpreters have come. More than an interpreter, Interactive-C is a fully-integrated development environment: a complete K&R interpreter bound tightly to its own editor and debugger.

Slice through programming projects like a hot knife through butter. Extensive error-checking insures immediate detection of program misbehavior. State of the art debugging tools include breakpoints, watchvalues, several stepping options and interactive viewing and modification of variables. An Interactive-C exclusive lets you interrupt to edit and "continue" from where you left off. Eliminates plodding replays of already debugged code—the ball and chain of other interpreters.

Operate Interactive-C using adjustable edit, command, and status windows. Toggle a second screen showing only your program's output—never any crowded intermixing. Or, boost productivity with twin CRTs. Load object code of functions you have already compiled. Or of commercial libraries. Interactive-C has immediate mode, syntax checking both as you type and run, and cursor positioning precisely pointing at an error, not possible with incremental or pseudo-compilers which leave source code behind.

100% compiler compatible—right down to header files and library calls. Port programs between Interactive-C and your compiler with no modifications whatever— not even tricky areas of dynamic memory allocation and I/O.

Specify: E950 & Compiler List: **$249** PC Brand: **$219**

DAN BRICKLIN'S DEMO PROGRAM

Storyboard Your Program

The Legendary One has created Metaphor Two when the rest of us are still on Zero. Dan's first was the original electronic spreadsheet (VisiCalc™). This one is for programmers.

Words don't express program ideas because programs are screens! Dan's Demo creates slide shows. Create a screen — a snapshot of your planned product as it runs. Anything goes: words, borders, box rules, inverse and underlining of monochrome, fore- and background color. Copy this "slide" to an empty screen. Change it a little, to show the next instant of run-time. Do it again. Presto, a whole slide show of your program in action.

All 250 characters and attributes are available from scrollable lists which pop to the screen. All commands are layered in Lotus-style pop-up menus. Frequent choices mapped to function keys as well. 80x25 character mode, not bit-mapped.

Screen areas can be blocked for cut and paste or filled with color or characters, even blink. Slides can overlay on others, can be shuffled, deleted. Slides can proceed at time intervals or branch anywhere in the slide sequence depending on user keyhits.

Invaluable to prototype the program you are about to write, to position the labels, choose the color decor, smoothe out the keystroke interface. Or load the "capture" utility and snapshot the screens of any running program for an instant slide show.

Each copy entitles you to redistribute fifty of the slide projector program that runs demos. Plain manual, no binder keeps price of big product small. "Might . . . become *the* essential tool in . . . user interface prototyping," *Tech Journal*. Ask for: N0100. List: **$75** US: **$69**

BASTOC OPTIMIZES!

Translates BASIC Into C

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Lattice 3.0. It will optionally convert your program into a single monolithic C function or decompose it into separate functions, one for each GOSUB label.

Version 2's optimization dramatically reduces execution time. Converts to integers those variables in BASIC programs which do not need floating point. Where BASIC uses full assignment statements to increment counters, BASTOC converts to C's compact form. Strings dynamically allocated ridding your application of BASIC's catatonic halts for garbage collection. Creates structure of even convoluted BASIC code. Huge worksaver.

Ask for:	List:	PC Brand:
S0375	**$495**	**$399**

Shopping List for the Power Workbench

ASSEMBLERS & DEBUGGERS	LIST	US
Advanced Trace-86 *Morgan, ASM Interpreter*	175	119
Codesmith-86 *Dubugger by Visual Age*	145	99
CSD Debugger *C source level by Mark Williams*	75	55
C-Sprite Debugger *by Lattice, source level*	175	139
Microsoft Macro Assembler *with Utilities*	150	109
PASM86 *by Phoenix, Macro Assembler*	195	144
Periscope I Debugger *Data Base Decisions*	295	235
Periscope II *Data Base Decisions*	129	99
Periscope II-X *software only*	115	74
Pfix86 Plus *by Phoenix, Symbolic Debugger*	395	279
BASIC LANGUAGE		
BetterBASIC *Summit Software*	195	165
BetterBASIC Utilities *8087 Math Support*	99	85
Btrieve Interface	99	85
Run-Time Module	250	225
Microsoft BASIC Interpreter *for XENIX*	350	295
Microsoft QuickBASIC Compiler *full BASICA*	99	79
Professional BASIC *by Morgan*	99	69
True BASIC *True BASIC Inc*	150	99
Run Time Module	150	99
True BASIC Libraries *Btrieve, Asyn, Sort, etc.*	Var	Call
C COMPILERS		
C-86 Compiler *Computer Innovations*	395	289
Lattice C Compiler *from Lattice*	500	299
Let's C Compiler *by Mark Williams*	75	55
with CSD Source Level Debugger	150	105
MWC-86: Mark Williams C Development	495	369
Microsoft C Compiler *4.0*	450	295
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	249
Instant C *by Rational Systems*	500	395
Interactive-C *by IMPACC with debugging*	249	219
RUN/C Professional *from Lifeboat*	250	185
RUN/C *without Loadable Libraries*	120	109
TEXT EDITORS		
Brief *from Solution Systems*	195	Call
Edix *by Emerging Tech...Multi-screen*	195	159
Epsilon *by Lugaru Software, like EMACS*	195	149
FirsTime *by Spruce Technology, C syntax*	295	229
Kedit *by Mansfield, similar to Xedit*	125	99
LSE, the Lattice Screen Editor *Multi Window*	125	100
Pmate *by Phoenix, with Macros*	195	149
Text Management Utilities *Grep, splat, diff, etc.*	120	100
Vedit *by Compuview*	150	99
Vedit Plus *by Compuview*	185	129
FILE MANAGERS		
Btrieve *by Softcraft, no royalties*	250	195
Btrieve Network *by Softcraft*	595	465
C-Tree *by FairCom - no royalties, source*	395	329
R-Tree *by FairCom-Report Generator*	295	245
C-Tree & R-Tree Combo *by FairCom*	650	541
dBC *dBASE file manager from Lattice*	250	195
with source	500	390
dbVista *single user DBMS by Raima*	195	139
with source	495	399
dbVista *multi-user DBMS*	495	399
with source	990	815
Opt-Tech Sort *Can sort Btrieve files*	149	105
SCREEN DESIGN		
Curses *by Lattice, UNIX screen designer*	125	99
with Source	250	199
Greenleaf Data Windows......*New*	225	169
with source	395	297
source purchased later	225	169
On-Line Help *from Opt-Tech Data*	149	105
Panel *by Roundhill, no royalties*	295	229
View Manager for C *by Blaise*	275	189
Vitamin C *by Creative Programming*	150	129

Windows for C *Vermont Creative Software*	195	149
Windows for Data *includes Windows for C*	295	259
ZView *Data Management Consultants*	245	175
GRAPHICS		
Essential Graphics *by Essential, no royalties*	250	210
GSS Graphics Development Toolkit	495	375
GSS Kernel System *by Graphic Software*	495	375
GSS Kernel System *for IBM RT*	795	645
GSS Metafile Interpreter	295	235
GSS Plotting System	495	375
Halo *by Media Cybernetics*	300	219
with **Dr. Halo II**	440	299
Halo for Microsoft *includes all fonts*	595	434
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	125
Greenleaf Communications *by Greenleaf*	185	139
PTel *by Phoenix, Binary File Communicator*	195	149
Software Horizons Pack 3	149	119
UTILITY LIBRARIES		
Blaise C Tools Plus	175	125
Blaise C Tools	125	89
Blaise C Tools 2	100	69
C Food Smorgasbord *by Lattice*	150	109
C Utility Library *by Essential, 300 functions*	185	139
Greenleaf Functions *by Greenleaf Software*	185	139
PforCe *by Phoenix, vast library*	475	349
Software Horizons *Packages*	Var	Call
TopView Tool Basket *by Lattice, source avail*	250	199
DEVELOPMENT TOOLS		
Code Sifter *by David Smith Software, Profiler*	119	89
C-Worthy *by Custom Design Software*	295	269
C-Worthy for Network *Menus, help, errors*	495	449
Dan Bricklin's Demo Program *Prototyper*	75	69
LMK from Lattice *by Lattice, "make" like UNIX*	195	149
Microsoft Window Development Toolkit	500	365
PC-Lint *by Gimpel Software, after UNIX's "lint"*	139	125
PFinish *by Phoenix, EXE performance analyzer*	395	279
Plink86 Plus *Utilizes memory for overlays*	495	359
Pmaker *by Phoenix, like UNIX "make"*	125	105
Pre-C *by Phoenix, UNIX "lint"-alike*	295	208
Pfantasy Pac *six Phoenix products*	1295	895
OTHER TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	399
BASIC-C *BASIC's functions added to C*	175	139
The HAMMER *by OES Systems*	195	139
Report Option *by Softcraft, Btrieve Report Gen.*	145	128
Xtrieve *by Softcraft, Query Utility for Btrieve*	245	220
FORTRAN COMPILERS & UTILITIES		
ACS Time Series *by Alpha Computer Service*	495	405
Forlib- Plus *by Alpha Computer Service*	70	45
Microsoft FORTRAN *Links with Microsoft C*	350	219
Microsoft FORTRAN *for XENIX*	695	546
RM/FORTRAN *by Ryan McFarland*	595	Call
Scientific Subroutine Package *by Alpha*	295	239
The Statistician *by Alpha Computer*	295	239
Strings & Things *by Alpha Computer*	70	45
OTHER LANGUAGES & UTILITIES		
Microsoft COBOL Compiler	700	499
Microsoft COBOL Compiler *for XENIX*	995	795
Microsoft COBOL Tools *with Source Debugger*	350	259
Microsoft COBOL Tools *for XENIX*	450	333
Microsoft Lisp *New Common Lisp*	250	189
Microsoft MuMath *includes MuSimp*	300	199
Microsoft Pascal Compiler *Links with M'soft C.*	300	199
Microsoft Pascal Compiler *for XENIX*	695	546
PDisk *Phoenix's new disk manager*	195	148
RM/COBOL *by Ryan-McFarland*	950	Call
RM/COBOL 8X *ANSI 85 COBOL*	1250	Call
Source Print *Aldebaran's diagrammer*	139	109

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NEW!

A Mighty Fortress Is Their FORTRAN

Picking over features of rival products is not necessary if FORTRAN is your need, still the citadel of scientific and engineering work. Ryan-McFarland has left the competition battering at the gates.

RM/FORTRAN™ is a complete implementation of FORTRAN-77 (ANSI X3.9-1978), the only PC FORTRAN certified by the General Services Administration at the highest test level. The reason: it's a big mainframe compiler moved to PCs, with the bonus that mainframe and mini applications can wander between environments.

Now, on your PC, you can develop large applications, with programs up to 640k (bigger using overlays), arrays over 64k, and using a long list of VS, VAX and FORTRAN-66 extensions you may have grown fond of — long symbolic names, "include", IRT bit functions — because R-M has left out nothing.

But what really sets RM/FORTRAN apart is optimization. The compiler reduces the number of instructions to the minimum which will actually execute, and even takes advantage of each processor's features to deliver lightning-fast object code. It runs 30%-40% faster than Microsoft 3.2, and could make your mainframe not worth the trouble.

Comes with an interactive symbolic debugger like that accompanying IBM VS FORTRAN, Plink86 subset, has a cross reference compile option, supports assembler and C subroutine calls, IEEE floating point, 8087 and 80287 chips.

"Compiler's documentation, ease of use, speed of execution, and debugger facilities place it first for recommendation," said the *Tech Journal* (10/85).

R-M has been writing FORTRAN compilers for IBM, DEC, etc. for 20 years. There is no greater expert.

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Lattice now delivers smaller .EXE files, boasts very fast link times and a more efficient aliasing algorithm. New options generate code to use 80186 and 80286 features; 8087 of course sensed and utilized. Lattice has enjoyed pre-eminence so long that developers have created far more snap-on tools for Lattice C than any other compiler. William Hunt's *PC Tech Journal* review of 12 compilers awarded Lattice the only "very good" rating for add-on library availability.

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S1201	Run-time Module	**$250**	**$225**
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COMPATIBILITY 286 PERFORMANCE

OUT FROM THE SHADOW OF IBM:

PC's Limited 286^{12}

Unreliability mars what otherwise would be an excellent value offered by the 12-MHz AT compatible from PC's Limited.

STEVEN ARMBRUST and TED FORGERON

The combination of massive advertising, a money-back guarantee, and rock-bottom prices has brought PC's Limited into the limelight of the mail-order computer business. At center stage in most of the company's advertisements is the PC's Limited 286^{12}, a PC/AT compatible that promises an almost unheard-of 12-MHz performance at a price thousands of dollars below that of IBM's original AT.

At the time this article was written, advertisements for the 286^{12} proclaimed the price to be $2,695 for a package that includes the system unit with 1MB of RAM on the system board, a single 1.2MB diskette drive, a combination diskette/hard-disk controller, and a keyboard. Some of the advertisements also claimed that the machine is equipped with two serial ports and one parallel port, but those items were not present on the machine tested for this article and the manual treats them as options. Other components not included in the base machine are a hard disk, monitor, and display adapter (see sidebar).

Neither DOS nor BASIC is supplied with the 286^{12}. Either PC- or MS-DOS (versions 2.0 or later) can be used, but PC's Limited advises using PC-DOS 3.1 or MS-DOS 3.11 or later. Version 3.2 (packaged with GW-BASIC) is available at extra cost from the company.

The test machine included the standard items, plus a 40MB Tandon hard disk, a 360KB diskette drive, the PC's Limited EGAds! graphics adapter, and a Princeton Graphics Systems HX-12E enhanced color monitor. The total price for this configuration when purchased from PC's Limited is $4,447—more than the advertised price, but still a good buy if the equipment works as advertised. Photo 1 shows the entire system. (PC's Limited now offers a package price for two configurations of the 286^{12}. The system unit with 1.2MB diskette drive, 30MB hard-disk drive, one parallel and two serial ports, EGAds! card, and 12-inch enhanced

PHOTOGRAPH • MARC DAVID COHEN


PRINCETON
Smart VU

PHOTO 1: *PC's Limited 286^{12} Styling*

PHOTO 4: *Keyboard Comparison*

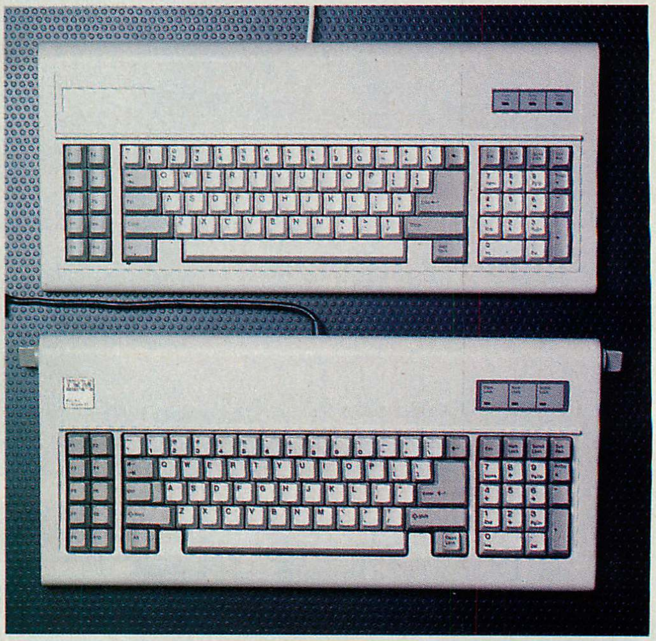


PHOTO 2: *System Unit Footprint*

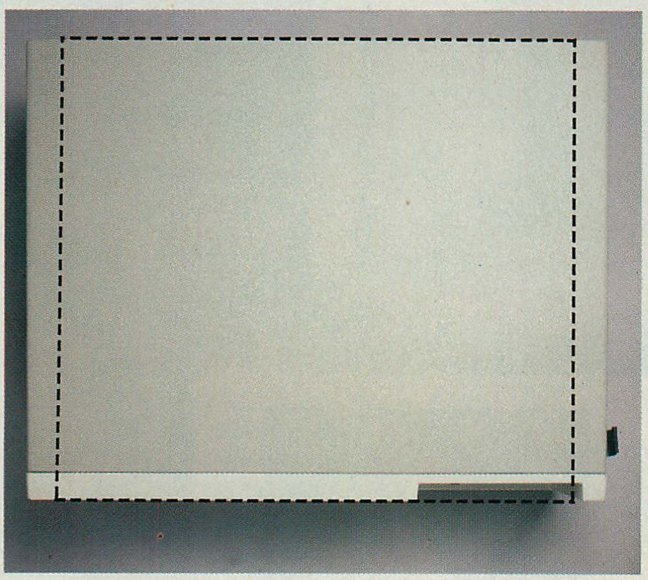


PHOTO 5: *Inside the System Unit*

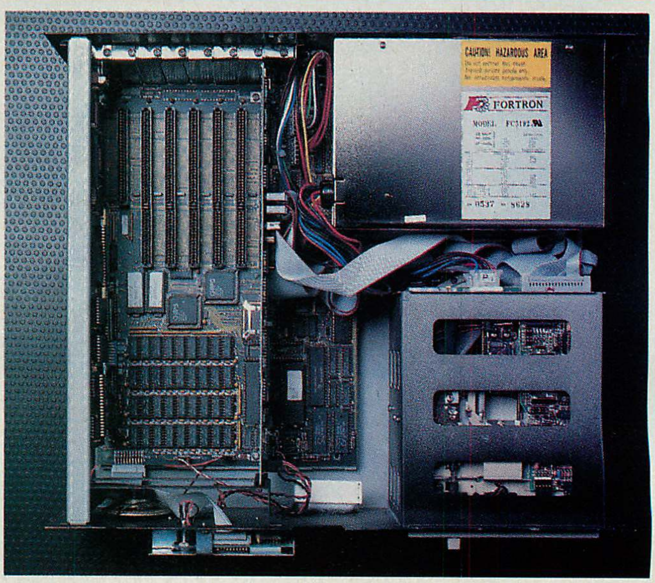


PHOTO 3: *SmartVU Display*

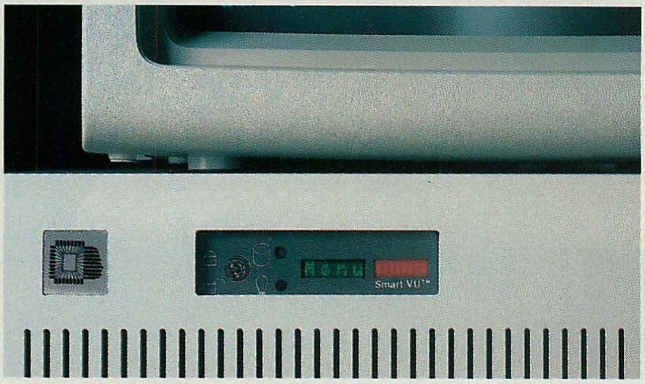


Photo 1: The PC's Limited machine comes standard with 1MB of RAM on the system board, a single 1.2MB diskette drive, and a combination diskette/hard-disk controller.

Photo 2: The PC's Limited system unit, which measures 18.75 by 16.5 by 6.5 inches, is 25 percent smaller than the AT's. The dotted lines indicate the size of the 286^{12}.

Photo 3: The SmartVU LED display panel provides several useful diagnostic functions on the 286^{12}, including the current track that is being read on the disk.

Photo 4: The PC's Limited keyboard layout (top) is similar to the original AT, but it provides little tactile feedback. The position of the Esc and tilde (˜) keys can be swapped.

Photo 5: The 80286 and 80287 sockets are located for easy access inside the system unit. The support brace on the left must be removed before access to slot 8 is possible.

graphics color monitor is priced at $3,595. The same package except with a 40MB hard-disk drive is $3,695.)

Because of its price tag, questions about the quality of the 286[12] naturally arise. Even with the low price, is the computer really a wise investment? Is it well engineered, or will it spend most of its time traveling to and from PC's Limited headquarters in Austin, Texas, for repairs? When it is first pulled from the box, the 286[12] exudes quality. The cabinet looks and feels like an IBM product, and the SmartVU panel on the front of the unit adds a high-tech flavor. Unfortunately, the computer tested for this article did not live up to its good-looking package or its advance billing.

Before testing could even begin, the unit had to be returned to PC's Limited three times for repairs. The SmartVU panel (the diagnostic read-out on the front of the system unit) failed twice, once accompanied by the unmistakable odor of burning insulation. A third problem involved the diskette/hard-disk controller, which failed to access the hard disk properly at 12 MHz. Until the controller was replaced, it destroyed files, crashed the system, and eventually did so much damage that the hard disk had to be reformatted.

After the unit was returned from PC's Limited for the third time, it developed another problem that prevented the warm reboot (Ctrl-Alt-Del) from working. Although the system booted when it was turned on, it ceased operating when a warm reboot was performed, and the following message appeared in 40-column mode on the screen: "Error 8259 #1 101 System Halted." Aside from this initial problem, though, the 286[12] worked almost flawlessly for the rest of the test period.

SMALL FOOTPRINT

From the outside, the system unit looks like an AT, except narrower. At 18.75 inches by 16.5 inches by 6.5 inches, it is actually 25 percent smaller than the AT. Photo 2 compares the footprint of the PC's Limited 286[12] with that of the AT.

The only apparent penalty imposed by the reduced footprint is in drive space: the 286[12]'s single storage bay is capable of holding only three half-height drives, whereas the AT's two storage bays can handle two half-height diskette drives and two full-height hard disks. The 1.2MB diskette drive is normally mounted in the 286[12]'s top bay. In the unit tested for this article, the middle bay contained a 360KB diskette drive, and the bottom bay contained a 40MB hard disk. This arrangement is not the only one possible. The diskette/hard-disk controller has cables for two diskette drives and two hard disks, so a second hard disk could be substituted for the second diskette drive without having to purchase another controller or extra cables.

One minor annoyance is that the 1.2MB diskette drive and the 360KB drive look identical when viewed from the front. Some companies place a large asterisk on the front of one drive to distinguish it; other companies provide access lights of different colors. Neither method is used on the 286[12].

Its small footprint notwithstanding, the 286[12] manages to house a full complement of eight expansion slots (two 8-bit slots and six 16-bit slots) and 1MB of RAM on its system board.

The front panel of the 286[12] system unit includes a key-lock switch, a flexible set of indicators, and the SmartVU panel, as shown in photo 3. The key lock is a miniature version of the AT's key lock and provides the same functions. Situated next to the key lock are a hard-disk access light and another indicator light, the function of which can be selected with a switch on the system board. In one setting, this light is simply a power indicator that is lit when power is on. In the other setting, the light indicates processor speed (off for 6 MHz, on for 12 MHz). Because the default operating speed is 6 MHz, most users will choose the latter setting, thus *creating* a visual reminder to switch to 12 MHz after booting.

Next to the indicator lights is the SmartVU diagnostic panel, the troublesome component that had to be replaced twice in the test unit. When it does work, SmartVU provides valuable feedback about system operations. The panel consists of two separate displays: a four-character alphanumeric LED display and a DIP consisting of a row of eight LED bars (see photo 3).

The alphanumeric display has four primary functions. First, it lists the names of the power-on routines during the boot process and displays error messages. On a machine that is operating properly, the names of the power-on routines (such as RAM1, RAM2, Optr, KB33, VMem, Int1, and Int2) flash by too quickly to be seen. If a problem develops, the name of the current test remains on the screen for a moment, then an error message appears. In the case of the test machine, whenever a warm reboot was performed the display stopped at the test Int2. Then the message "Error 8259 #1 101" appeared on the screen and also scrolled across the SmartVU display.

The second function of the alphanumeric panel is to display the processor speed whenever it changes. Pressing Ctrl-Alt-\ toggles the processor between 6 and 12 MHz; then the computer beeps and the alphanumeric display lists the new processor speed.

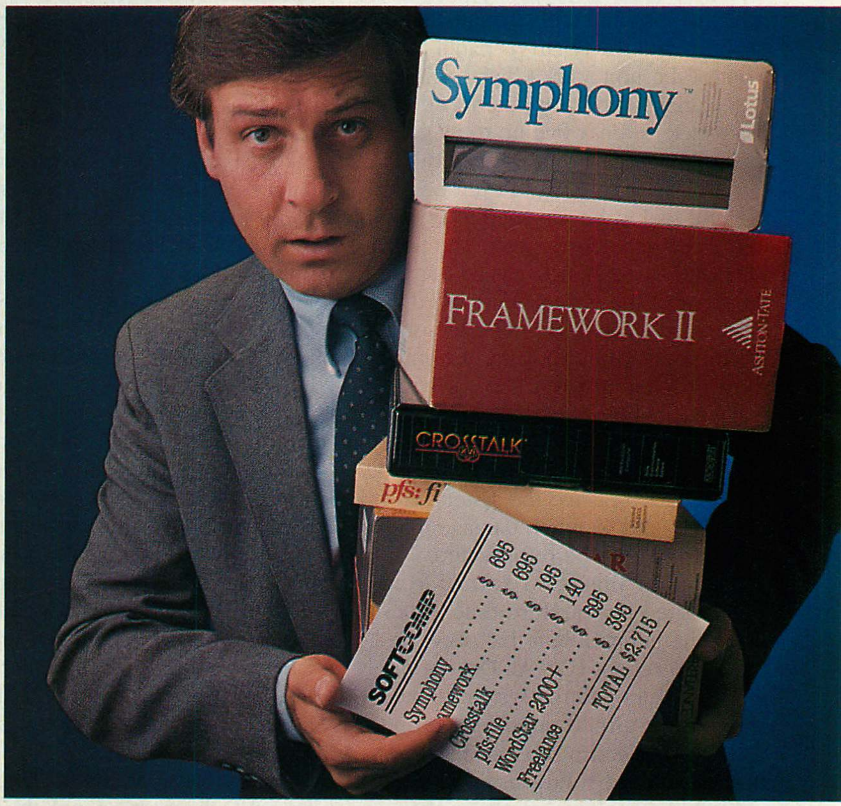
The third panel function should especially please those users who are adamant about having access lights on their disk drives. Whenever a drive is accessed, the panel displays the drive letter, followed by the two least significant digits of the sector that is being accessed. This can be helpful while debugging programs, if only to give hints about whether a program is accessing the drives at the expected times. The sector numbers do not provide much explicit information, but they do make it easier to estimate the amount of data being accessed. With large amounts of data, the numbers fly by; when quick accesses are performed, only a short burst of sector numbers appears.

The fourth function of the alphanumeric panel is to display error mes-

PC'S LIMITED 286[12] VITAL STATISTICS

PC's Limited 286[12]: $ 2,695	**Available slots**
1MB memory	(after adding display adapter and serial/parallel card)
Realtime clock	16-bit: 5
1.2MB diskette drive	8-bit: 0
Memory capacity on system board	**Options available**
1MB	Monochrome display adapter $ 159
Display adapters	EGAds! adapter $ 269
None provided	Serial/parallel card $ 199
Expansion slots	12-inch enhanced graphics color monitor $ 479
16-bit: 6	30MB hard disk $ 699
8-bit: 2	40MB hard disk $ 819

THE BAD NEWS ISN'T THE PRICE.



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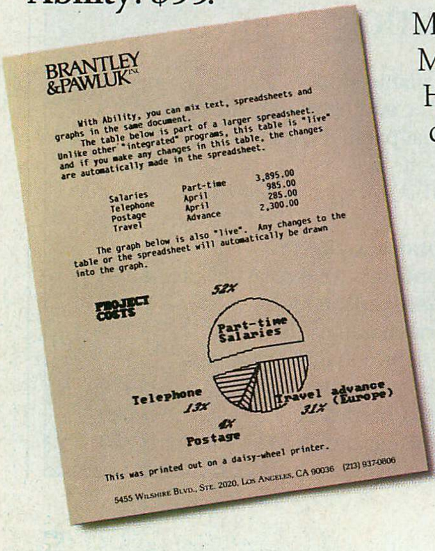

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sages during system operation. These messages can indicate a CPU failure, a memory problem, or even a low-battery indicator for the realtime clock. Table 1 lists the error messages.

The second display of the SmartVU panel consists of an array of eight LEDs. Once the system has been booted, a light flashes back and forth across this eight-element display, indicating that the system is operational. The individual lights are related to timer interrupts. When an interrupt occurs, the LED currently on is switched off and the next one in sequence is switched on. If the lights stop flashing, it is an indication that the CPU has halted for some reason or that interrupts have been disabled. This display is useful in determining whether a program has really crashed or is just taking a long time for computation. The lights can be disabled if the flashing becomes too distracting.

The Princeton Graphics Systems HX-12E monitor and the PC's Limited EGAds! adapter that were included in the test unit provide features similar to IBM's Enhanced Graphics Adapter (EGA) and Enhanced Color Display. Although a full test of the EGA's compatibility was not performed for this article, the EGAds! card exhibited no trouble handling software that uses the EGA's special video modes (such as Microsoft Word and Windows). The EGAds! card is a three-quarter length, sparsely populated card that contains the Chips and Technologies (C&T) EGA chip set. (For a review of the EGAds! card, see "The EGA Spectrum, Part 1," John T. Cockerham, October 1986, p. 80.)

As might be expected from an inexpensive compatible, the 286[12]'s keyboard is a lightweight model that provides little tactile feedback, although the F and J keys do have ridges to help keep fingers positioned properly on the home row. Manufactured by the Maxi-Switch Company, the keyboard features a layout that is virtually identical to that of the original IBM AT. Photo 4 compares the two keyboards.

One interesting note about the keyboard is that it can be used on both AT- and PC/XT-compatible computers. A switch on the underside of the keyboard sets the mode; another switch lets users swap locations of the Esc and tilde (˜) keys to place the Esc key back in its original, top-left location.

OPERATING AT 12 MHz

The 286[12] comes with 1MB of RAM on the system board, rated for 100-nanosecond (ns) access time so that it will work properly with a 12-MHz 80286.

TABLE 1: *SmartVU Display Panel Error Messages*

MESSAGE	DESCRIPTION
Er02	80286 failure
Er03	Multiple RAM errors in the first 64KB
Er04	Video RAM failure
Er05	ROM checksum error
Er06	Parity error status bit cannot be reset
Er07	8254 timer failure
Er08	Programmable array logic or RAM refresh failure
Er09	8742-controlled Gate A20 not operating well in virtual-86 mode
Er10	Virtual-86 mode exception error, extended memory failure, or 8742 failure
Er11	The 14-MHz crystal is shorted or inoperable
Battery Low	The battery powering the realtime clock is low

The SmartVU LED display panel, when it works, provides a list of error messages to help pinpoint system errors, including a low battery for the realtime clock.

The system board is extremely flexible in its method of RAM allocation between conventional and extended memory. The default configuration is 640KB of conventional and 384KB of extended memory; it also can be divided into 512KB for both types of memory, or only conventional memory can be assigned. This option is useful when bad memory chips are suspected, because the user can exchange memory chips from the unused extended memory to replace the bad chips.

Unfortunately, the manual for the 286[12] mentions only the 512KB/512KB option, even though the switches are set at the factory for 640KB/384KB. Furthermore, the manual warns that when the 640KB option is chosen, the remaining memory cannot be accessed, but the factory-selected 640KB/384KB option does permit use of the additional 384KB as extended memory.

The 286[12]'s 12-MHz operation is a performance bonus. The default 6-MHz operation permits speed-sensitive programs, such as games and copy-protected software, to run without difficulty. At any time, however, the user can toggle to 12 MHz by using the Ctrl-Alt-\ key combination. PC's Limited does not provide a way to set the processor speed through programming.

One side effect of the 12-MHz operation can be good or bad, depending on the expansion cards running in the computer. When the CPU is switched into 12-MHz mode, the expansion bus runs at 12 MHz as well. This is ideal for cards that can handle the smaller bus cycles, but many popular expansion cards, such as the Intel Above Board and the Cheetah memory card do not function at that speed; in that case, the entire computer, including the CPU, must be switched back to 6-MHz mode.

The 286[12] contains an option menu, including the entire set-up program, in ROM; it is activated by pressing Ctrl-Alt-Enter. The menu options are listed as they appear on the screen:

- Configure hardware
- Disable RAM parity
- Enable RAM parity
- SmartVU scan off
- SmartVU scan on
- Park fixed disk heads
- List SmartVU diagnostic summary
- Resume program
- Restart system

This menu provides access to the set-up utility for specifying the number and type of disks, the amount of memory available, the type of display adapter used, and the presence or absence of a numeric coprocessor. The option menu also lets users disable or enable RAM parity or SmartVU's array of lights, park the heads on the hard disk, and list the SmartVU error codes.

Because the entire option program resides in ROM, it can be accessed and the options changed—even when an application program is running. However, accessing the option menu while running other application programs is not recommended. If the user accesses the set-up portion of the program—for example, to view the current settings—then the only way to leave the program is to reboot the computer. Of course, rebooting means that any data not saved before the option menu was activated will be lost.

Even if the user wishes to switch off the SmartVU panel or to look at a

list of the error messages, the option menu still should not be invoked from within application programs. Although the program can be resumed, the previous screen is not restored.

INSTALLING HARDWARE

Installing hardware in the 286[12] is for the most part easy. The metal cover of the system unit is fastened with three easily accessible screws on the rear panel. A medium-sized Phillips screwdriver can be used to remove them, as well as any other screws in the system unit. The cover, which wraps around like the AT's cover, slides forward and tilts up and off.

One difficulty arises if any one of the drives installed by PC's Limited needs to be removed. These drives are fastened to the storage bay by two screws, one on each side of the bay. Removing the screw next to the outside edge of the computer is easy, but the screw on the side next to the expansion cards poses a problem; it requires either a very short screwdriver or the removal of the disk adapter card from the slot adjacent to the bay.

Adding and removing expansion cards is as easy in this machine as in the AT, with the exception of slot 8 (the slot next to the edge of the system unit). Directly above this slot is a support brace that must be removed in order to gain access to the slot. Photo 5 shows the inside of the system unit with this support brace visible.

The 286[12] does not include plastic card guides to steady and align the expansion cards when they are inserted. Because most expansion boards come with a card guide, however, this lack should not prove to be a problem.

Other areas of the system unit are easily accessible. The 80286 and 80287 sockets are placed so that neither the power supply nor any drive needs to be removed to gain access to the chips. The 80286 is in a leadless chip carrier (LCC) socket with an AMP-type socket cover. The socket cover can be tricky to remove, but it is manageable. When the socket cover is removed, the label on the underside of the chip verifies that the processor is rated at 12 MHz.

The system board's switch settings are labeled on the board next to the switch—a nice touch that enables the switches to be set without using the manual. This label includes the relevant switch settings for the amount of memory that is installed. The switches for the 80287 socket are similarly labeled.

As photo 5 also shows, the system board of the 286[12] contains six 16-bit and two 8-bit expansion slots, even though the 286[12]'s board is considerably smaller than that of the AT. The disk adapter normally resides in the 16-bit slot next to the power supply. In the test unit, the EGAds! adapter was placed in one of the 8-bit slots. If serial and parallel ports are desired, another expansion slot is required for their use. Therefore, five slots are actually available for optional expansion cards.

The four C&T components used on the system board are one reason the board can contain a full complement of expansion slots and still fit in a small-sized chassis. These custom components provide the same services that are normally provided by many general-purpose components; thus, they take up less area on the board.

The 286[12]'s half-height, 40MB Tandon hard disk had a slightly better performance rating than that of the AT. The average access time for the Tandon

The system board of the 286[12] contains the full eight expansion slots (six 16-bit and two 8-bit) even though the board is considerably smaller than that of the AT.

drive was 34.1 milliseconds (ms). Because DOS cannot manage disks larger than 32MB, PC's Limited provides a device driver called SPLIT_1.SYS that splits the disk into two logical drives, C: and D:, enabling the entire disk to be accessible. Of course, for this device driver to work, FDISK must be used to set up two DOS partitions on the drive. This operation is normally performed by PC's Limited before shipping the drive. The tested drive was set up for 32MB in drive C: and 8MB in drive D:.

The 286[12] supports IBM drive types 1 through 15 for users who would like to add their own drives. The disk drive housing does not look as if it would cause any problems with the installation of third-party, half-height drives, and the standard mounting kits supplied with such drives should be adequate. Full-height drives also will fit, but different mounting hardware may be necessary in order to install them.

The power supply, manufactured by Fortron, is rated at 192 watts. Typical power consumption at 110 volts is 27 watts with a 1.2MB diskette drive, a 360KB diskette drive, and a 40MB hard disk installed in the system unit.

TESTING 1, 2, 3

Like the other computers reviewed in this series, the 286[12] underwent two kinds of tests. First, a set of commonly used hardware and software products was installed to check for compatibility. Then the *PC Tech Journal* AT Evaluation Suite of compatibility and performance tests was run, and the results were compared with an 8-MHz AT.

The add-on hardware products installed in the PC's Limited 286[12] for these tests included an 80287 numeric coprocessor, the Intel Above Board AT with 4MB of memory, a Cheetah zero-wait-state RAM card, the PC's Limited EGAds! card, Microsoft serial and bus mice, an IBM game adapter, and the Hayes Smartmodem 1200B. An IBM parallel/serial adapter also was added for use with the serial mouse and to check whether or not the software products tested could access these ports.

The software products that were used included Microsoft Windows and Word (to test graphics capabilities and the mice); SuperKey, SideKick, and Turbo Lightning, all from Borland International (to test memory-resident programs); Ready! from Living Videotext and Intel QUIKMEM (to test expanded memory); Hayes Smartcom II (to test the communications port); IBM VDISK (to check extended memory); Fastback from Fifth Generation Systems (to check direct memory access); and the IBM SETUP and Advanced Diagnostics programs (to perform a general check-up on the PC's Limited system).

A major hardware problem occurred when the computer was set to run at 12 MHz. At that setting, neither the Above Board nor the Cheetah memory card would function reliably. The Above Board's diagnostic program (TESTAB) reported that two complete banks of memory were bad. These problems occurred because at the 12-MHz setting, both the processor and the expansion bus run at 12 MHz. Neither the Above Board nor the Cheetah card is rated for use at that speed. If either one of these cards is to be used, the 286[12] must be set to run at 6 MHz.

All of the software products tested worked properly, even at 12 MHz. Software that depended on the expanded memory in the Above Board was tested only at 6 MHz. Even the IBM AT Advanced Diagnostics ran at the 12-MHz speed without detecting an error.

TABLE 2: *Results of Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	PC's LIMITED 286[12], 40MB DISK (at 12 MHz)
ATBIOS		
ROM BIOS date	11/15/85	06/14/86
ATPERF		
Average RAM instruction fetch (μs)	.403 (100)[b]	.262 (153)
Average RAM read time (μs)		
BYTE	.401 (100)	.262 (153)
WORD	.401 (100)	.262 (153)
Average RAM write time (μs)		
BYTE	.401 (100)	.262 (153)
WORD	.401 (100)	.262 (153)
Average ROM read time (μs)		
BYTE	.401 (100)	.262 (153)
WORD	.401 (100)	.262 (153)
Average video write time (μs) (CGA only)		
BYTE	1.208 (100)	1.210 (100)
WORD	2.415 (100)	2.410 (100)
Average EMM read time (μs)		
BYTE	.402 (100)	.262 (153)
WORD	.402 (100)	.262 (153)
Average EMM write time (μs)		
BYTE	.402 (100)	.262 (153)
WORD	.402 (100)	.262 (153)
CPU clock rate (MHz)	8.0 (100)	12.0 (150)
Math coprocessor clock rate (MHz)	5.3 (100)	8.0 (150)
Refresh overhead (%)	7.1	4.6
RAM read wait states	1	1
RAM write wait states	1	1
ROM read wait states	1	1
Video write wait states (CGA)	8	12
EMM read wait states	1	1
EMM write wait states	1	1
ATFLOAT		
Performance as percentage relative to AT	100	150
ATDISK		
Sectors/track	17	17
Heads	5	5
Cylinders	731	975
Total space (million bytes)	31.81	42.4
Track-track seek time (ms)	6.0	5.4
Average seek time (ms)	37.1	34.1
Effective transfer rate (KB/sec)	170.1	169.9
DOS File I/O (sec)	7.3	7.1
Interleave	3	3

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the PC's Limited 286[12] are taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*

The expanded memory manager (EMM) measurements are shown in this table, even though the Intel Above Board did not work reliably at 12 MHz. The ATBIOS results did not provide the manufacturer of the BIOS in this case. The bus is running at the 12-MHz speed of the processor itself when in the faster mode.

After all the add-on hardware and software products were tested, the *PC Tech Journal* AT compatibility and performance tests were run. These tests perform the following functions: ATBIOS checks the BIOS and BIOS data area; ATKEY checks for keyboard compatibility; ATPERF measures CPU and numeric coprocessor clock rates as well as memory access times; ATFLOAT measures floating-point operations with the numeric coprocessor installed; and ATDISK measures hard-disk performance. (See "Out from the Shadow of IBM . . . ," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52, for a more detailed description of these programs.) All of these tests were run with the 286[12] at its 12-MHz speed setting. Table 2 lists the results.

ATBIOS showed that the 286[12] uses the data area in the same way that the AT does. The area normally used for the copyright statement merely stated that the machine was IBM compatible; as a result, the designer of the BIOS could not be identified.

ATPERF indicated that the processor, numeric coprocessor, and the expansion bus all were running at a higher speed than in the 8-MHz AT. The 80286 does indeed run at 12 MHz, and the 80287 runs at 8 MHz. The numbers for the Intel expanded memory manager (EMM) read and write times show that access to the expansion bus is also at 12 MHz. The EMM measurements are included in table 2 even though the Above Board does not work reliably at the 12-MHz speed.

ATFLOAT also showed that floating-point operations were performed faster with the 286[12].

ATKEY verified that the keyboard was compatible with the AT keyboard. In fact, the IBM AT keyboard worked when plugged into the 286[12].

ATDISK determined that the Tandon hard disk slightly exceeded the performance of the AT hard disk. With an interleave of 3, the effective transfer rate was almost identical to the AT.

CONFUSING DOCUMENTATION

The owner's manual for the 286[12] provides the minimum amount of information necessary to operate the 286[12], but just barely. Although it claims not to speak "computerese," the manual defines only a few of the terms it uses. Its major error is in failing to mention the option that divides memory into 640KB of conventional memory and 384KB of extended memory. This omission, along with warnings about the 640KB setting, might lead the user to believe that the

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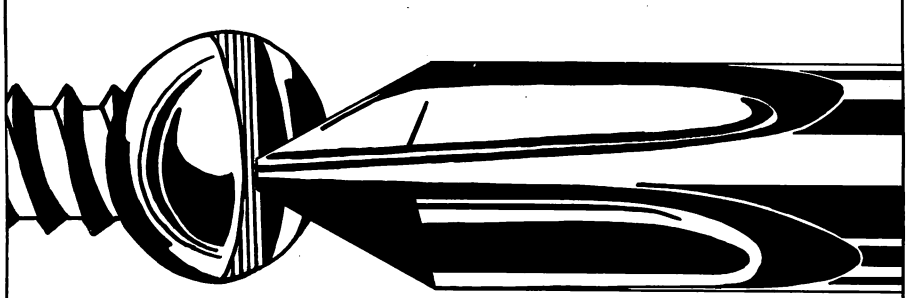

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extended memory in the computer is not an option.

The manual does not include an index—a definite disadvantage. It is spiral-bound, so it lies flat when in use. No technical reference manual is available for the 286¹², and because no software is shipped with the machine, no manuals describing DOS or BASIC are included either.

PC's Limited offers an excellent warranty and service plan, and judging from the test machine's performance, many users will need to take advantage of it. A 30-day, money-back guarantee and a one-year warranty are offered by PC's Limited; it offers a toll-free support line, which is staffed by courteous, knowledgeable people. Users also can contact PC's Limited via Telex, facsimile machine, or MCI Mail.

RELIABLE BARGAIN?

The PC's Limited 286¹², if it works, offers a good value for the price, but if the unit tested is any indication, the machine has significant reliability problems. Contacting PC's Limited and sending the computer back was never a problem. The support staff was always eager to help. However, users who cannot afford any down time might become frustrated by the necessity to help PC's Limited do the testing and evaluation that should have been performed earlier by the company itself.

In addition, because the 286¹² runs both the processor and the expansion bus at 12 MHz, this fast mode might not work with many of the expansion cards currently in use. In order to use such hardware, the computer must be run at the slower 6-MHz setting, and at 6 MHz, the 286¹² is hardly a bargain.

To its advantage, the 286¹² was able to run every software package that was tested, even at 12 MHz. Once PC's Limited learns how to build reliability into this computer, the 286¹² will be an excellent buy, especially for users who do not have old expansion cards that they must use.

286¹²
PC's Limited
1611 Headway Circle, Building 3
Austin, TX 78754
800/426-5150; in Texas, 800/252-8336
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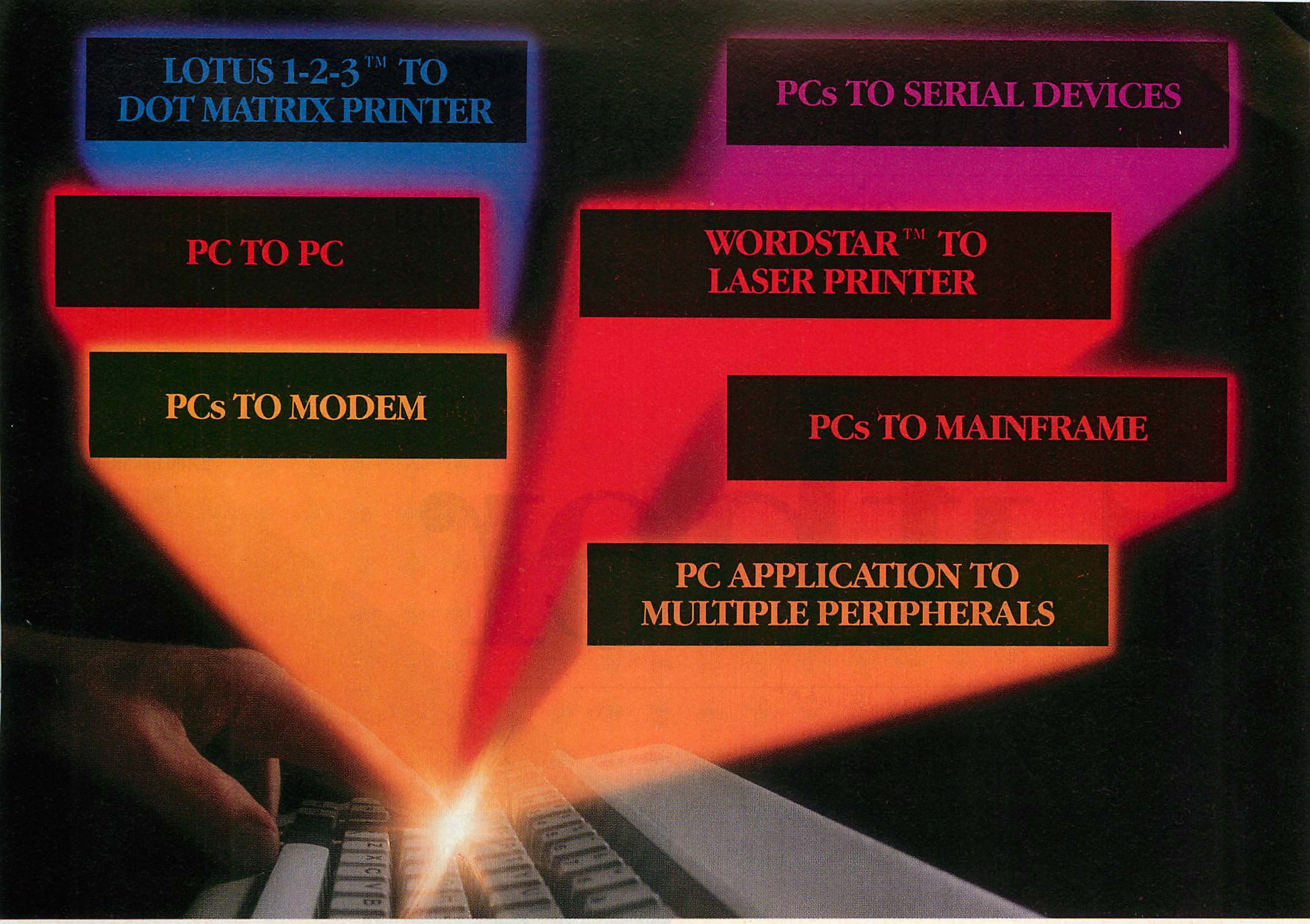
Steven Armbrust is a freelance technical writer, and Ted Forgeron is software project manager for Intel Scientific Computers. Together, they are the authors of the Programmer's Reference Manual for IBM Personal Computers *(Dow-Jones Irwin, 1986).*



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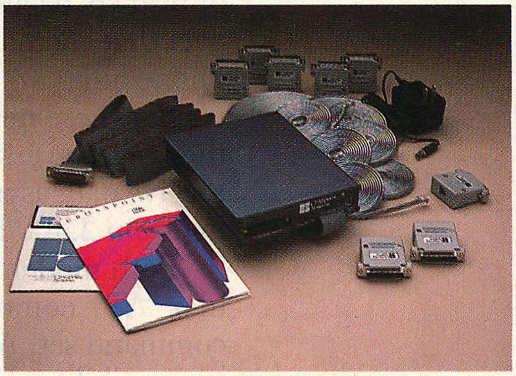

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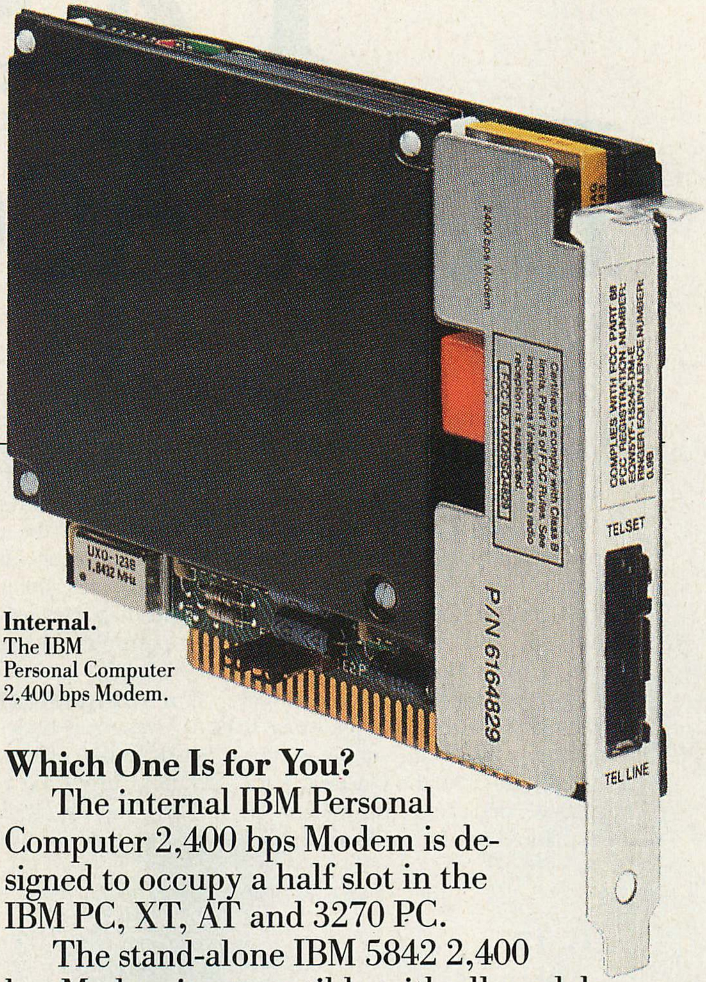
or



Internal.
The IBM
Personal Computer
2,400 bps Modem.

The Automatic Modems

These modems feature Automatic Adaptive Equalization at 2,400 and 1,200 bps—which means they will continuously fine-tune themselves to compensate for changes and noises on the telephone line. The result is, you can receive data over a wider range of telephone line conditions.

Both modems also feature automatic or manual answering and dialing. They'll automatically switch to pulse dialing if tone dialing doesn't work. They have automatic redialing. And once a connection is made, automatic speed detection. They also have automatic detection of a voice or a failed call.

A Modem with a Memory of Its Own

The stand-alone IBM 5842 2,400 bps Modem offers some additional features. It can also send and receive data synchronously at speeds of 2,400 bps or 1,200 bps. You'll find extensive "Help" menus. A dial directory for 20 phone numbers. A log-on directory for five log-on sequences. A built-in pattern generator for self testing. Diagnostics implemented from the front panel as well as from the computer keyboard. And a complete array of LED Status Indicators to give you a quick visual check on what's happening.

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Desktop Data Acquisition

In the scientific laboratory, data acquisition and analysis programs are playing an increasingly important part in the manipulation of experimental data. Similarly, such programs can be used in a variety of industrial applications to control simple processes.

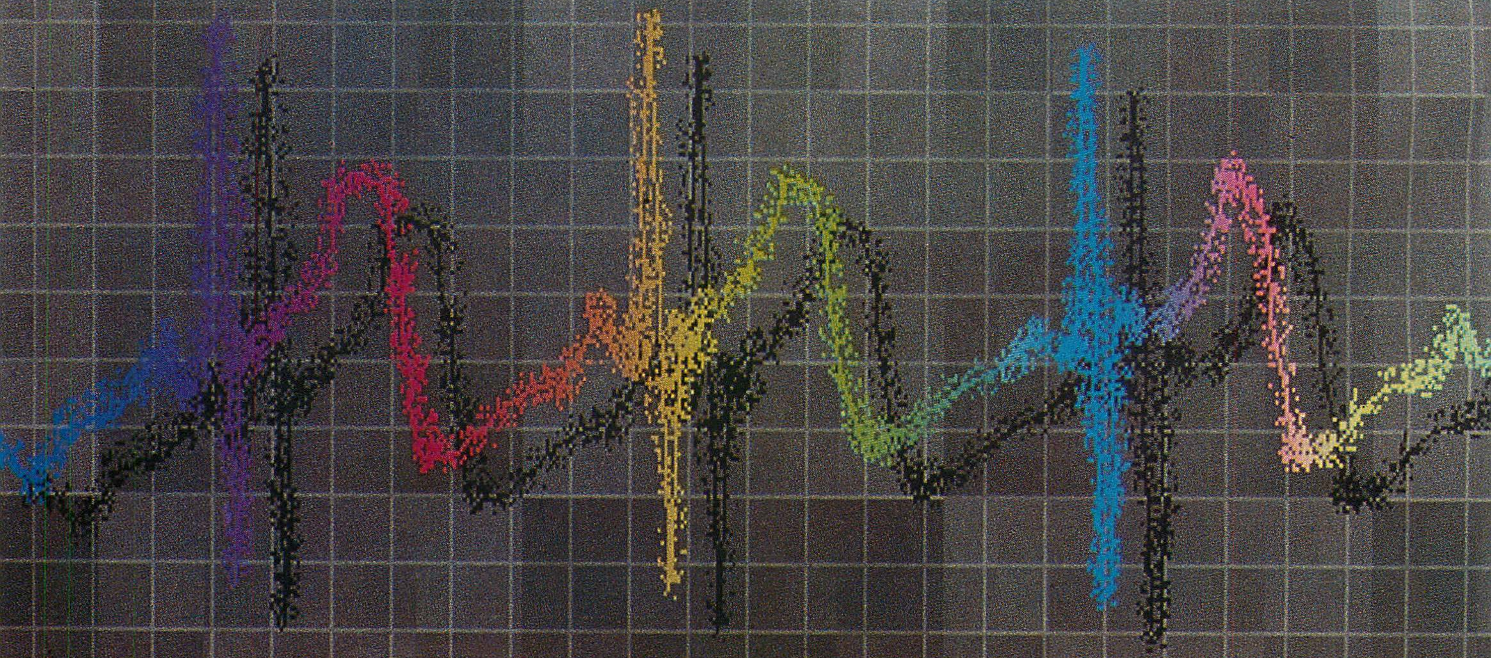
Macmillan Software's ASYSTANT+ converts the IBM PC and compatibles into a desktop data acquisition and analysis system comprising several virtual instruments. For many applications that can tolerate moderate sampling rates, ASYSTANT+ can take the place of more expensive, dedicated instruments—albeit at a loss in ultimate performance.

The basic version of the program, ASYSTANT, converts the PC into a sophisticated calculator. To that basic capability, the more advanced version, ASYSTANT+, adds the ability to control a data acquisition accessory. ASYSTANT+'s capabilities are similar to those of a sister product, ASYST, which provides a FORTH interpreter-like user interface.

A SOPHISTICATED CALCULATOR

ASYSTANT+'s basic user interface is similar to that of a stack-oriented, handheld, electronic programmable calculator, such as the various Hewlett-Packard (HP) models. In fact, the main screen display is referred to as the desktop calculator and resembles a calculator in functionality. It is divided into five windows, four of which correspond to the facilities of an advanced programmable calculator (see photo 1). The fifth window contains the main options that access other parts of the program, such as waveform processing and generating, graphics, and curve fitting.

The calculator windows are stack contents, calculator functions, parameters, and variables. Three other calculator menus—array operations, conversions and special functions, and wave and matrix operations—can be inter-



ASYSTANT+ from Macmillan Software provides sophisticated data acquisition for scientists and engineers from a desktop computer.

VICTOR E. WRIGHT

changed with the calculator functions (see figure 1). Each calculator menu includes the selection, **next**, to display the next calculator menu.

A key concept in learning to use ASYSTANT+ is that of the stack—an area of memory used for temporary data storage. Data can be placed on the stack from the keyboard or from other storage areas, and can be removed from the stack to be placed in other storage areas. Most operations and functions take their arguments from the stack and leave their results on the stack. HP calculator users and FORTH programmers should be comfortable with the system.

The program begins with a cursor positioned on the first selection of the main menu, **acquire**. Pressing PgUp moves the cursor to the calculator functions menu. This gives the expected assortment of mathematical functions and stack operators—**store**, stores the entry at the top of the stack in a parameter or variable; **dup**, duplicates the top entry in the stack; **drop**, drops the entry at the top of the stack; **swap**, switches the top two entries on the stack; and **roll**, places the bottom entry on the stack on the top and pushes the other entries down one. A status selection allows the user to select the format of numeric output: angular units for use with trigonometric functions, and data type—integer, double-precision integer, real, double-precision real, complex, or double-precision complex.

Calculator commands can be entered by moving the cursor to the desired selection with the arrow keys and pressing Enter or by typing them at the keyboard. When a number, letter, or operator is typed, the main menu window clears and a command line area appears in its place, regardless of the location of the cursor.

Commands can be entered in Reverse Polish Notation (RPN) used by HP

COMPUTER GRAPHIC • NATALE/EAST

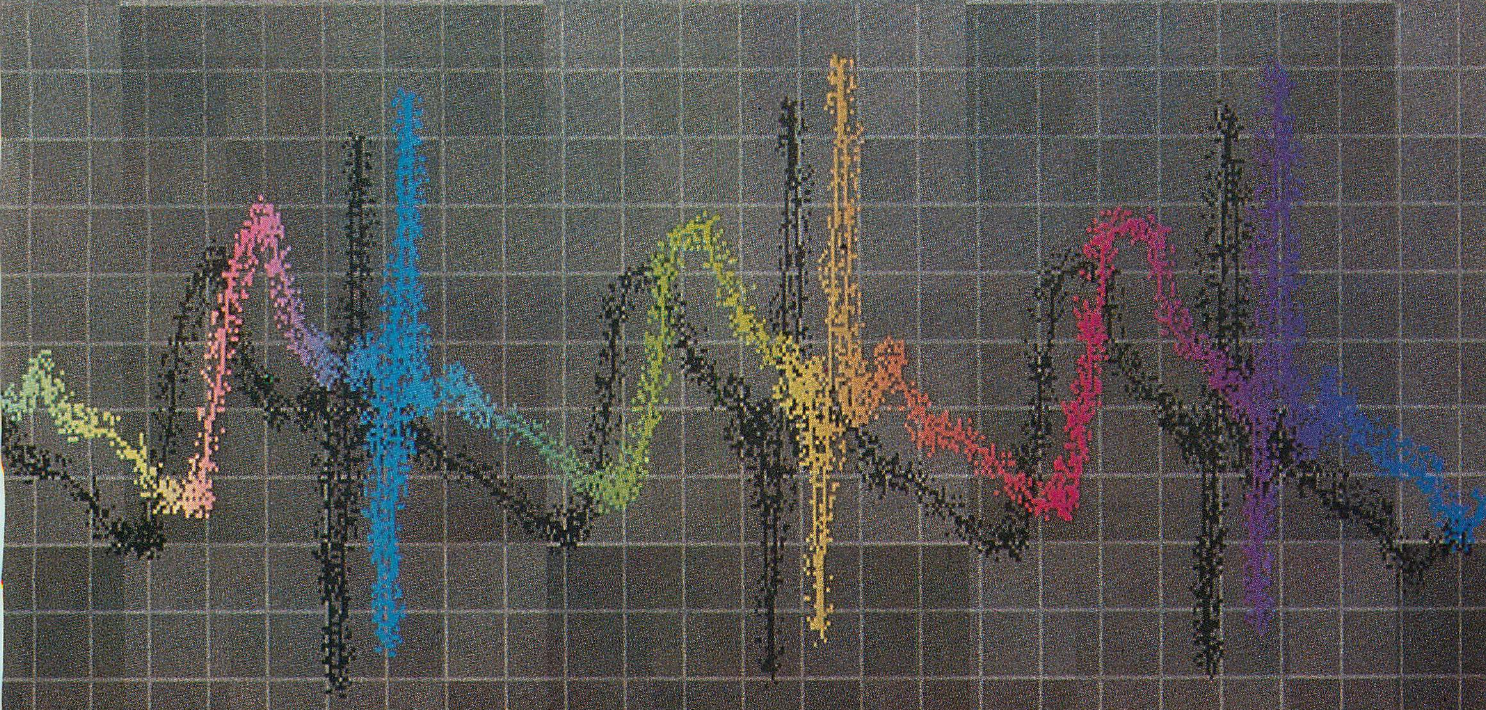
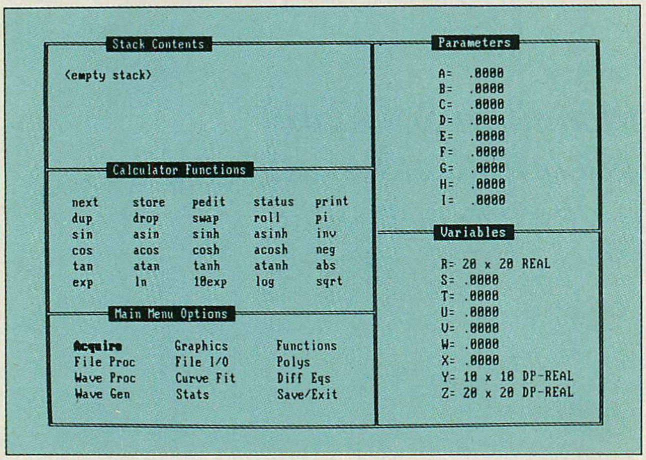
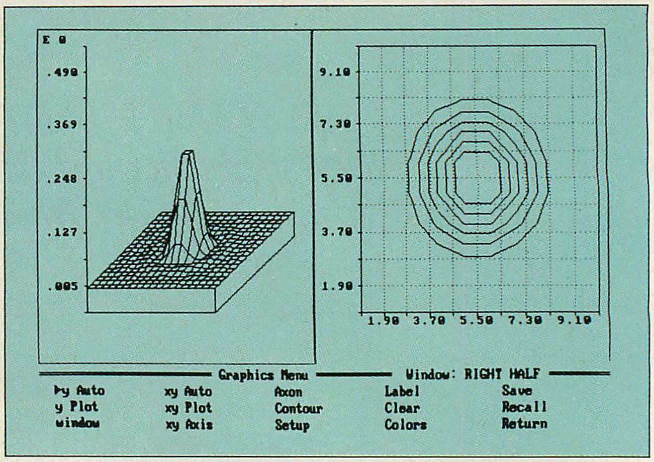


PHOTO 1: *Calculator Functions Menu*



The calculator functions menu is replaced with the array menu, the conversion and special functions menu, or the wave and matrix menu by selecting the "next" option.

PHOTO 2: *Window Options*



The screen can be split into a variety of windows by selecting the windows option, and each window can then be used to display data independently.

and FORTH or in algebraic notation. The program expects RPN; an algebraic notation always must be preceded with the \ character. Commands can be entered in strings and then are terminated with the Enter key. Entering a valid number places a result on the stack. ASYSTANT+'s stack is limited to five entries, which are displayed in the stack contents window. Stack entries can be integers, real numbers, complex numbers, or arrays of integers, real numbers, or complex numbers.

In the calculator menu, macros ("user functions") can be assigned to the ten function keys. Each key can be assigned up to five lines of RPN or algebraic notation. Pressing a function key while in the Calculator executes the macro. The macro assigned to one key can include the name of another key, so that additional functions may be performed by a single macro.

The parameters and variables windows on the main screen display provide two types of storage registers, nine of each. Parameters, *A* through *I*, store numbers; and variables, *R* through *Z*, store either numbers or arrays. Parameter and variable values can be copied to the stack, and stack entries can be copied or moved to the parameter and variable registers. Parameters and variables are available in all parts of the program, and they can be assigned descriptive names.

VECTORS AND MATRICES

The array operations menu is displayed by selecting the **next** option from the calculator functions menu. It offers a set of commands to create and manipulate arrays. ASYSTANT+ provides for two types of arrays; one-dimensional arrays, or vectors, and two-dimensional arrays, or matrices. An array occupies one slot on the stack or one variable. Arrays cannot be stored in parameters.

The program uses two 64KB segments of RAM for storage of arrays. One segment contains the arrays assigned to the variables *R* through *Z*, and the other segment contains any unnamed arrays on the stack. A single array can occupy an entire 64KB segment.

The array operations menu offers selections for the basic vector and matrix operations. Three commands, **n:ramp**, **nm:ramp**, and **aedit**, generate unnamed arrays and place them on the stack. **N:ramp** takes the top entry on the stack as the size of a one-dimensional array (vector) and replaces it with a vector in which the i^{th} element contains the value i—the value of each element is equal to the index. **Nm:ramp** takes the top two entries as the number of rows and columns of a two-dimensional array and replaces them with an array in which the ij^{th} element contains the value $(i-1)m+j$—i is the row index and j is the column index.

The commands **xsect**, **sub**, **trans**, **diag**, and **reverse** access certain array elements. **Xsect** takes the top element of the stack and replaces it with an element, **sub** with a subarray, **trans** with the transpose of the array, **diag** with the main diagonal, and **reverse** replaces the top element of the stack with an array with reversed column indices.

Arrays can be reordered with the commands **n:rot**, **reshape**, **sort**, and **lookup**, and they can be indexed with **index** and **n:search**. Two commands combine two arrays to form a third; **cat** stacks the two arrays one over the other, and **lam** places them side by side. Cumulative operations can be performed on the rows of an array to calculate sums and products and find cumulative maxima and minima.

Arrays can be examined in spreadsheet format with the array editor function, **aedit**. Arrays can be created directly with **aedit** or with another command, **n:ramp**, **nm:ramp**, **lam**, or **cat**, for example, and then edited. They also can be built and edited by using other menu options and functions, but using the array editor is the easiest way to make minor changes.

Switching to the third calculator menu, conversions and special functions, provides an assortment of options for converting data from one coordinate system to another, or from one data type to another, as well as special advanced functions. Numbers can be converted from a pair of values on the stack, one real and one imaginary, into a single complex entry on the stack. A single complex entry can then be split into a pair of values.

Data sets representing coordinates can be converted between Cartesian coordinates and polar coordinates or spherical coordinates. Also, complex numbers in the form $x + jy$ can be converted to the polar form. (Note that *PC Tech Journal* is using the electrical engineering notation j for the imaginary part of the complex number rather than the mathematical form i.)

The more advanced functions include the error function, factorials, the number of combinations of things taken r at a time from a set of n things, the number of permutations of things taken

r at a time from a set of *n* things, the Bessel functions, elliptic integrals, the gamma function, and the incomplete beta function.

The wave and matrix menu, the fourth calculator menu, offers several numerical techniques for the analysis of waveforms and matrices. Storing waveforms as arrays allows the use of many operations for the analysis of waveforms or matrices. A series of waveforms can be stored in a two-dimensional array, one waveform per row.

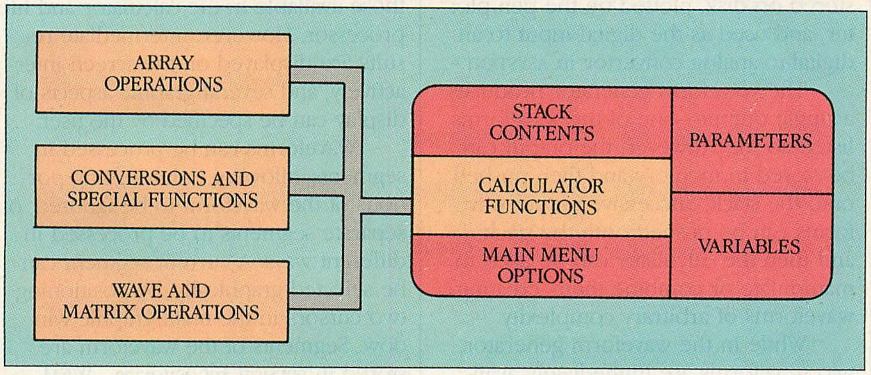
Once the waveforms have been stored, two functions, **smooth** and **window**, are available to filter them. The **smooth** function, a low-pass filter, removes high-frequency components of a waveform in the time domain, to eliminate noise in a signal, for example. The **window** function simulates a Blackman window, filtering out selected high and low frequencies. This function is better suited to waveforms stored in the frequency domain.

A waveform can be integrated by using Simpson's 1/3 rule or differentiated by using interpolating polynomials of a user-specified degree, as many as seven. Four functions are provided for Fourier transformations: fast Fourier transforms and inverse fast Fourier transforms for both one- and two-dimensional arrays. An additional function calculates the power spectrum (the square of the magnitude of the Fourier transform) of an array.

Other matrix operations included in the fourth calculator menu are the autocorrelation function, which is applied to the top entry on the stack; the aperiodic convolution of the top two entries; the application of a Blackman window to a subset of the top entry; the Hilbert transform of the top entry; and the cross correlation of the top two entries. By combining these advanced functions, the user can filter signals with low-pass or band-pass filters to remove noise or isolate signal components, process images, generate spectral analysis displays, generate diffraction patterns, and analyze signals in both the time and frequency domains.

The program performs the basic statistical operations, average, standard deviation, maximum, and minimum. A single operator is provided to solve the matrix equation, $y = Ax$. The operator expects the y vector as the top stack entry, and the A matrix (n by n) as the second entry. It replaces these two entries with the x, or solution, vector. Additional matrix functions are available, they include commands to return the trace of a matrix (the sum of the diagonal elements), the matrix product of two arrays, the Kronecker product of two arrays, the determinant of a matrix, and the inverse of a matrix.

FIGURE 1: *Calculator Menus*



ASYSTANT+'s available calculator menus provide a versatile selection of mathematical functions for manipulating the obtained waveforms and matrices.

CHOOSING FROM THE MENU

The main menu of ASYSTANT+ provides 11 options that enhance the versatility of the program. These options include, graphics, a waveform generator and processor, two file operations, users functions, curve fitting, polynomials, statistics, differential equations, and a data acquisition menu.

Graphics. ASYSTANT+'s graphics commands allow data to be displayed on the screen, on a graphics printer, or on a pen plotter. Graphics boards, printers, and plotters are selected from menus at the beginning of the initial session, and the selection can be changed at the beginning of any session thereafter.

Arrays are used to store graphics data. Two types of graphic displays can be generated, Cartesian plots and three-dimensional plots. Cartesian plots include line graphs of a single vector variable or a row of a rectangular array, plotted as a function of the indices; and line graphs of two vector variables or rows of rectangular arrays, with one variable or row taken as the independent variable and the other as the dependent variable.

Three-dimensional representations include axonometric plots and contour plots of two-dimensional arrays (shown in photo 2). An axonometric plot displays a surface representing the values of the plotted array superimposed over a rectangular grid; the height of the surface above the grid is proportional to the value of the array element. A contour plot displays a series of contour lines superimposed over a grid with the contour lines connecting elements of equal magnitude.

The graphics display is available to preview graphics before plotting. The default screen display includes a graphics menu and a graphics window. The graphics window can be split into left and right halves, upper and lower halves, and four quarters.

ASYSTANT+ is able to produce a plot with a minimum of information, by using default values and scaling the axes to display all of the data in a single plot. The **Setup** command gives the user the ability to customize the plot by specifying minimum and maximum values, linear or logarithmic scales, labels, grids, and the location of the origin. Whenever an IBM Enhanced Graphics Adapter (EGA) is used, the axes, labels, background, and plot can be displayed in different colors.

Users also can customize graphics windows with the addition of text labels. Labels can be positioned and aligned as desired. The contents of a graphics window can be saved to disk, and recalled at a later time for display.

A graphics display is generated by selecting the type of plot —**y Auto**, **y Plot**, **xy Auto**, **xy Plot**, **xy Axis**, **Axon**, or **Contour**. The program prompts for the variable to be plotted and then displays a menu that includes the selections **display graph** and **to plotter**; these selections produce screen displays and plots.

Waveforms. ASYSTANT+ includes both a waveform generator and processor. The generator creates arrays of values that represent a variety of continuous waveforms typically available from analog function generators. These include sine waves, cosine waves, square waves, triangular waves, sawtooth waves, pulses, uniform noise, white noise, and Poisson pulse trains. In addition to selecting the type of waveform, the user can control the gain, bias, and frequen-

cy of the waveform. These created arrays can be displayed on the screen, stored on disk, plotted on the pen plotter, and used as the digital input to an digital-to-analog convertor in ASYSTANT+.

The waveform generator produces a single output—one of the waveforms listed above. However, the output can be stored in memory and then pushed onto the stack. Successive output waveforms can be pushed onto the stack, and then the calculator can be used to manipulate or combine them, creating waveforms of arbitrary complexity.

While in the waveform generator, two waveforms are immediately available: the output of the generator and a waveform stored in memory. The output waveform can be added to the memory waveform to create complex waveforms without leaving the generator. Waveforms can be plotted on either the screen or the plotter.

The waveform processor provides a graphic alternative to the calculator for processing one-dimensional arrays (waveforms) or specified rows of two-dimensional arrays. The waveform processor display includes a large window in which a waveform is displayed, a series of small windows that summarize the history of the wave processing session, and a menu of commands.

The commands available in the waveform processor are a subset of those available in the calculator and file processor. However, intermediate results are displayed on the screen interactively, and several graphic aspects of display can be specified by the user.

Waveforms can be processed in segments, allowing uninteresting portions of the waveform to be ignored, or separate segments to be processed in different ways. A current segment can be selected graphically, by positioning two cursors in the main graphic window. Segments of the waveform are stored in several *repositories*—WFM (waveform), ORG (original segment), MEM (memory segment), PRV (previous segment), and SEG (current segment). Images of the repositories are shown at the top of the screen for reference; contents of MEM and SEG can be combined with selections from the waveform processor's memory ops menu.

Processing options include scaling the waveform with a fifth-degree polynomial, clipping SEG to a specified minimum and maximum, computing the derivative of the waveform (to a user-specified order), computing the integral, smoothing the current segment, computing the power spectrum, and finding the envelope of the waveform.

An analysis menu provides selections to find the basic statistics, rise time, fall time, area under the curve, and width of a specified peak.

Data file operations. Two submenus from the main menu are devoted to file operations: file I/O, and file processor. File I/O provides the basic facilities for storing and retrieving data associated with variables and for converting data files into files that can be used by other programs. The program supports two external formats: DIF and ASCII.

ASYSTANT+ data files are physically composed of a block of comments followed by a series of data subfiles. Logically, the file can consist of comments and data sets. Both subfiles and data sets contain multiple data points, and both are limited to 64KB, which corresponds to the area in RAM that ASYSTANT+ sets aside for the storage of variables. A data file can contain several blocks that may represent various aspects of a model or experiment.

ASYSTANT+'s file I/O menu allows subfiles and data sets to be selected as rectangular sections of a group of arrays. Even though the data file is actually a linear sequence of values, data can be addressed by row and column number, just as if the data were arranged in two dimensions. Data sets can be selected by specifying values or by scrolling through the file graphically.

The file processor menu integrates calculator functions and disk I/O functions. The processing capabilities of the desktop calculator and the file processor are identical. However, the file processor allows the user to specify the data source, the operations to be performed, and the destination for the results. The actual processing can be allowed to proceed unattended, whereas processing with the desktop calculator usually must be performed step by step.

Curve fitting. The curve fitting of ASYSTANT+ gives an interactive environment for fitting smooth curves through *x-y* data sets. Results are displayed as mathematical values and in graphic form.

The fitted curve can be specified as linear, polynomial, logarithmic, exponential, multilinear, or user-defined. Multilinear fits operate on one rectangular array and one vector, and the remaining fits operate on two vectors. The *goodness of fit* is determined by the least-squares fitting method.

Both the original data and the fitted curve are displayed, superimposed in a graphic window. The residual error curve is plotted in a separate window.

Polynomials. An extensive set of polynomial operations can be performed

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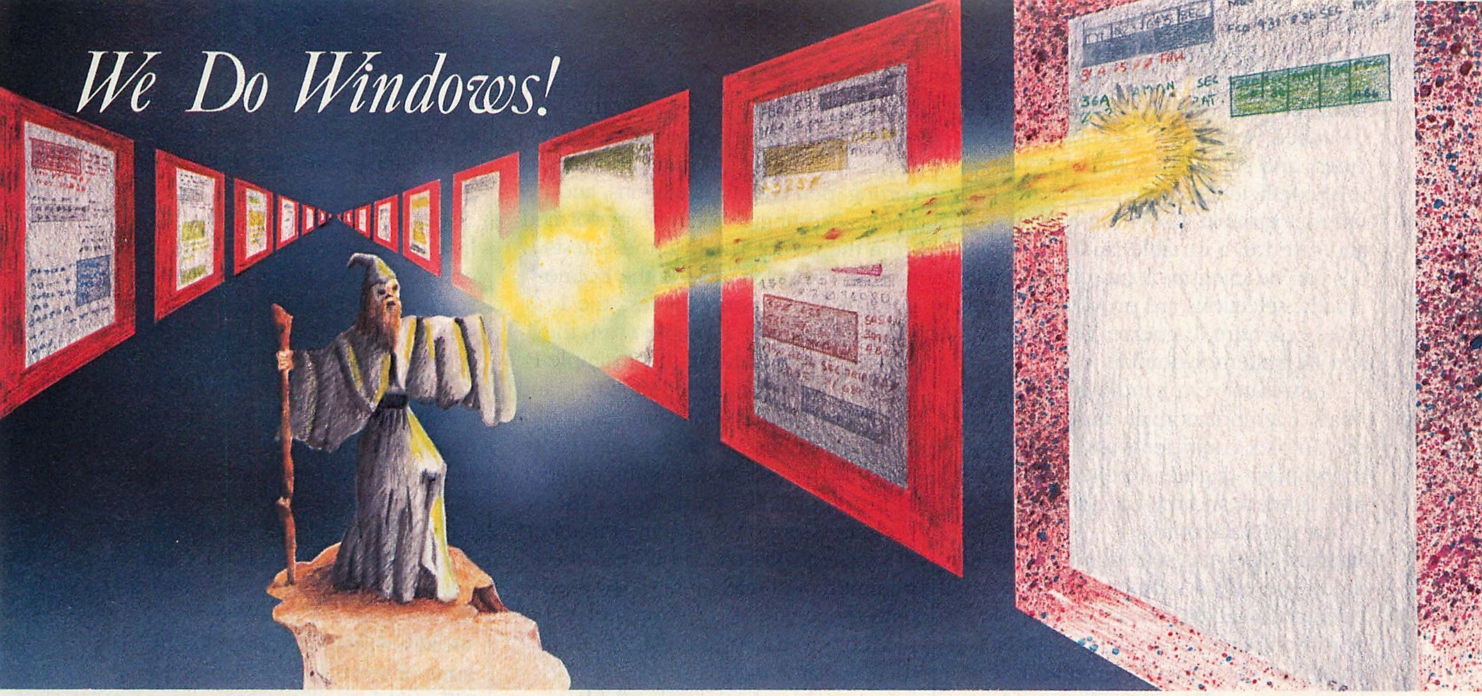

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from the polys menu. Polynomials can be added, subtracted, multiplied, divided, and shifted by a factor. Polynomial coefficients can be edited and copied to a variable. Roots can be extracted and saved in a variable, and polynomials can be integrated and differentiated. Finally, selections are provided to generate Legendre, Laguerre, Tchebyshev, and Hermite polynomials.

ASYSTANT+ can handle 10 polynomials. Each polynomial can contain real or complex coefficients and can be up to the ninth degree. A polynomial is first defined, and then it can be applied to the top stack entry.

Statistics. The stats selection of the main menu presents a submenu of statistical operations and messages. An edit function is available to allow the user to create or edit a data table without leaving the menu. The stats editor is identical to the array editor that is provided in the desk calculator.

The basic stats option computes and displays the basic statistics for a variable or subset of a variable. The statistics displayed include the maximum value, the minimum value, the sum of the values, the mean, the median, the variance, the standard deviation, skewness, kurtosis, the sum of the squares, and the root mean square. These values are displayed in a window on the screen and can be sent to the printer. Other basic statistical functions such as sorting, percentile calculations, and hypothesis testing also can be performed from the menu. The hypothesis tests that are provided include the Kolmogorov-Smirnov normality test, the 1 sample *t* test, the 2 sample *t* test, the 1 sample chi-square test, the 2 sample F test, the Wilcoxon signed-rank test, and the Mann-Whitney rank-sum test.

Histograms can be generated and plotted. The user specifies the number of breakpoints between "bins". The program sets up the specified number of bins, equally spaced between the minimum and maximum data values. Once generated, the histogram can be plotted, saved to a disk file, or left in the calculator variables.

A menu selection is available to generate commonly used frequency distributions. These include both percentages and percentiles of the normal distribution, the chi-squared distribution, the student *t* distribution, and the $F(n,m)$ distribution.

Two advanced analysis techniques are provided by ASYSTANT+. Stepwise regression is included with three variations of the analysis of variance (ANOVA) technique, one-way, two-way, and table. The ANOVA techniques indicate which of several independent variables are most significant in explaining the variations in the dependent variable. ASYSTANT+ displays the results of ANOVA in a table listing the sum of the squares, the degrees of freedom, the mean sum of the squares, the F-value, and the significance level of the F-value for each component and the residuals.

The regression option allows the construction of a model representing a dependent variable as a linear function of several independent variables. A vector holds the dependent variable, and an array holds the independent variables. The technique is interactive. Terms can be entered into and removed from the model with a few keystrokes; this allows several combinations of terms to be examined easily.

Differential equations. ASYSTANT+ provides a numerical method for solving first-order differential equations, ranging from a single equation to a system of five equations, using the fourth order Runge-Kutta method. Up to six variables are used, the *X* variable for the independent variable, and *Y*, *Z*, *U*, *V*, and *W* for dependent variables.

The model to be examined is specified by entering the system of differential equations, the initial conditions, and extrapolation parameters, consisting of step size used to generate the solution curves and the final *X*-value. Solution curves are stored in variables that can be displayed on the screen under the graphics menu, saved to disk, or sent directly to the plotter.

Notepad. ASYSTANT+ includes a simple screen editor, the notepad, which is available from both text and graphics screens by pressing Ctrl-N. The manual cautions that the notepad is not intended to take the place of a word processor; however, the editor is equal to the task of taking notes during experiments and creating simple reports.

The notepad is limited to straight ASCII text files with no control characters (such as the ones inserted by most word processors), 16KB total file size, and 80-character lines. Arrow keys and function keys are implemented, to provide cursor movement by character, word, line, word, and file. A limited set of block operations is available, as well as search and replace capability.

Text can be inserted into the current notepad file when the editor itself is inactive. ASYSTANT+ stores the current file name, and a cursor location. The calculator functions menu includes a print command that sends the top stack entry to the screen, printer, or current

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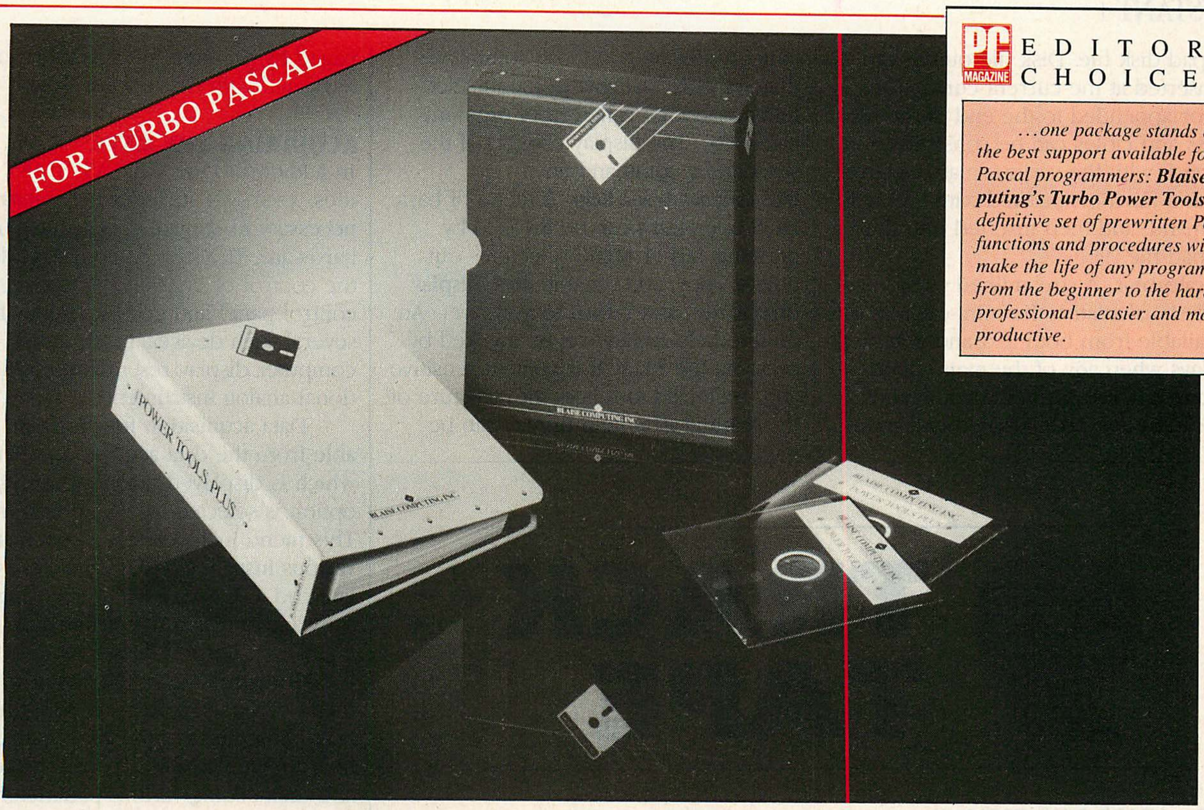

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notepad disk file. Disk file output can be inserted at the current cursor location or appended to the end of the file. Charts and tables can be constructed in the stack with the various matrix operators and functions, edited with the **aedit** command, and then inserted into the notepad file.

Mini-calculator. A streamlined version of the desk calculator, the mini-calculator, is available from both text and graphics displays when any of the main menu options is active. Only the command line can be used for input; menu input is not available, and those commands that are only available as menu selections cannot be called from the mini-calculator. The display consists of the stack and a command line.

DOS commands and help. A menu of basic DOS operations can be invoked by pressing Ctrl-D. Menu selections can delete, copy, and rename files, display directories, and return to ASYSTANT+. An on-line help facility can be invoked by pressing the ? key. It is context sensitive and organized to follow the structure of the manual. The help display can be paged by pressing the Space Bar, or navigated with the function keys.

ACQUIRING THE DATA

In addition to the basic ASYSTANT facilities, ASYSTANT+ includes the software necessary to control data acquisition hardware, The host computer, under the control of ASYSTANT+, becomes the control panel and graphic display for several such devices. In each case, the computer display resembles a traditional analog instrument.

Data acquisition functions are available from the data acquisition menu, which is displayed when the **acquire** option is selected from the main menu. This menu includes selections for the various instruments ASYSTANT+ can emulate and a selection for configuring the software to match the data acquisition board or external chassis.

Configuration of the system is menu-driven. It consists of selecting the host computer and the data acquisition board from lists of supported devices and then setting various parameters to match the physical configuration of the data acquisition board. The manual astutely warns the user that determining the physical configuration of the hardware may not be a trivial matter. A detailed appendix provides information about the configuration of supported boards; it is presented clearly and concisely enough to replace most data acquisition board manuals for standard applications.

It should be noted that configuration involves specifying the host computer as well as the data acquisition board, even though the program is in use on the host computer. The program must know the clock speed of the host computer to perform timing tasks.

Data acquisition board parameters that are specified during the configuration process include the board's I/O address, the number of A/D channels, the A/D channel voltage range, the hardware gain, the number of D/A channels, and the D/A voltage range. ASYSTANT+ does not necessarily support all of the features and configurations of supported boards, but the manual documents the ones that are.

Additional configuration parameters, selected from the acquisition configuration menu include confirmation that a hardware scroller board (a high-speed, strip-chart recorder) is installed, the specification of engineering units to be used in file conversion, color assignments for A/D channels when an EGA board is installed, the assignment of names to channels, and a bit pattern to

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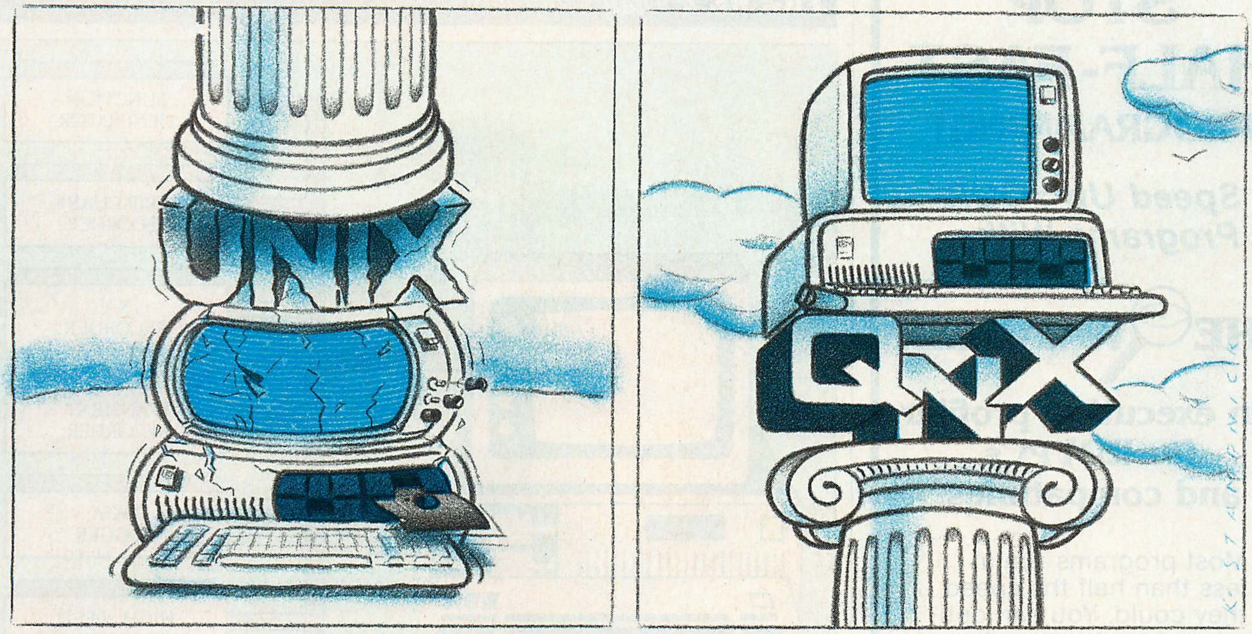

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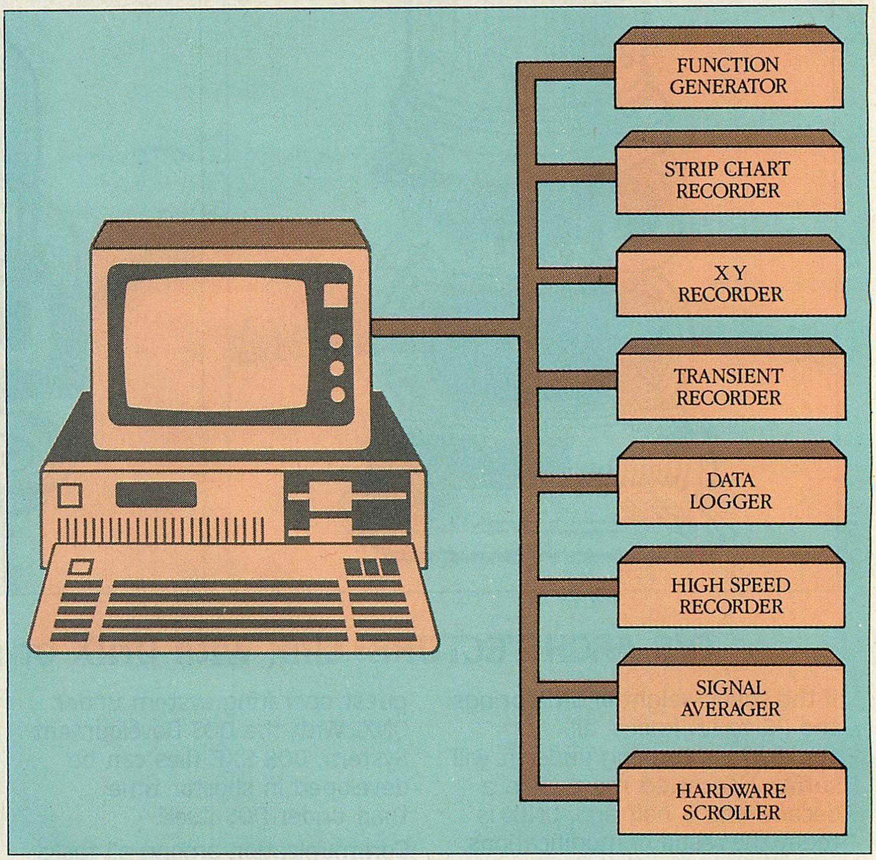
FIGURE 2: *Data Acquisition Menu*



Although the accuracy that can be obtained from a PC-based data acquisition system does not match that of individual laboratory instruments, ASYSTANT+ does manage to provide an economical solution for moderate sampling rates.

be set on the digital output port at the beginning of a data acquisition session. A final option is the selection of an unprotected mode. ASYSTANT+ normally operates in a protected mode, in which it prevents acquisition of data at sampling rates above that known to be reliable (the Nyquist rate). The unprotected mode allows the user to specify higher sampling rates at the risk of hanging the system, requiring a reboot.

With the data acquisition board installed and configured, ASYSTANT+ provides the user with the ability to select the preferred interface, or *metaphor*, from the data acquisition menu. Each selection performs the same basic task, that of controlling the data acquisition board, but it resembles a different laboratory instrument (see figure 2).

ASYSTANT+ can simulate a strip-chart recorder, a hardware scroller (if one is installed), an XY recorder, a transient recorder, a data logger, a high-speed recorder, a signal generator, and a function generator. When an instrument is selected, the program displays a submenu including options to set or modify instrument parameters, to begin acquiring data, and to return to the data acquisition menu. Set-up parameters can be saved to disk and recalled.

In general, acquisition parameters are common to all of the instruments; although some of them require the specification of additional parameters. ASYSTANT+ displays the current parameters on a configuration screen, along with appropriate limitations, and prompts the user for new values. The parameters required to set up a general-purpose instrument for a session are trigger type, internal or external clock, number of analog input channels, the first channel in a scan cycle, value for the software gain, the acquisition rate, the number of data points per channel, the number of scans to perform in the session, and the file to be used for data storage (file storage is optional).

Because data acquisition boards typically multiplex several analog input channels through a single analog to digital converter and have limits on the speed at which they can operate, these parameters are interrelated. For example, in the high-speed recorder mode, the maximum acquisition rate is in-

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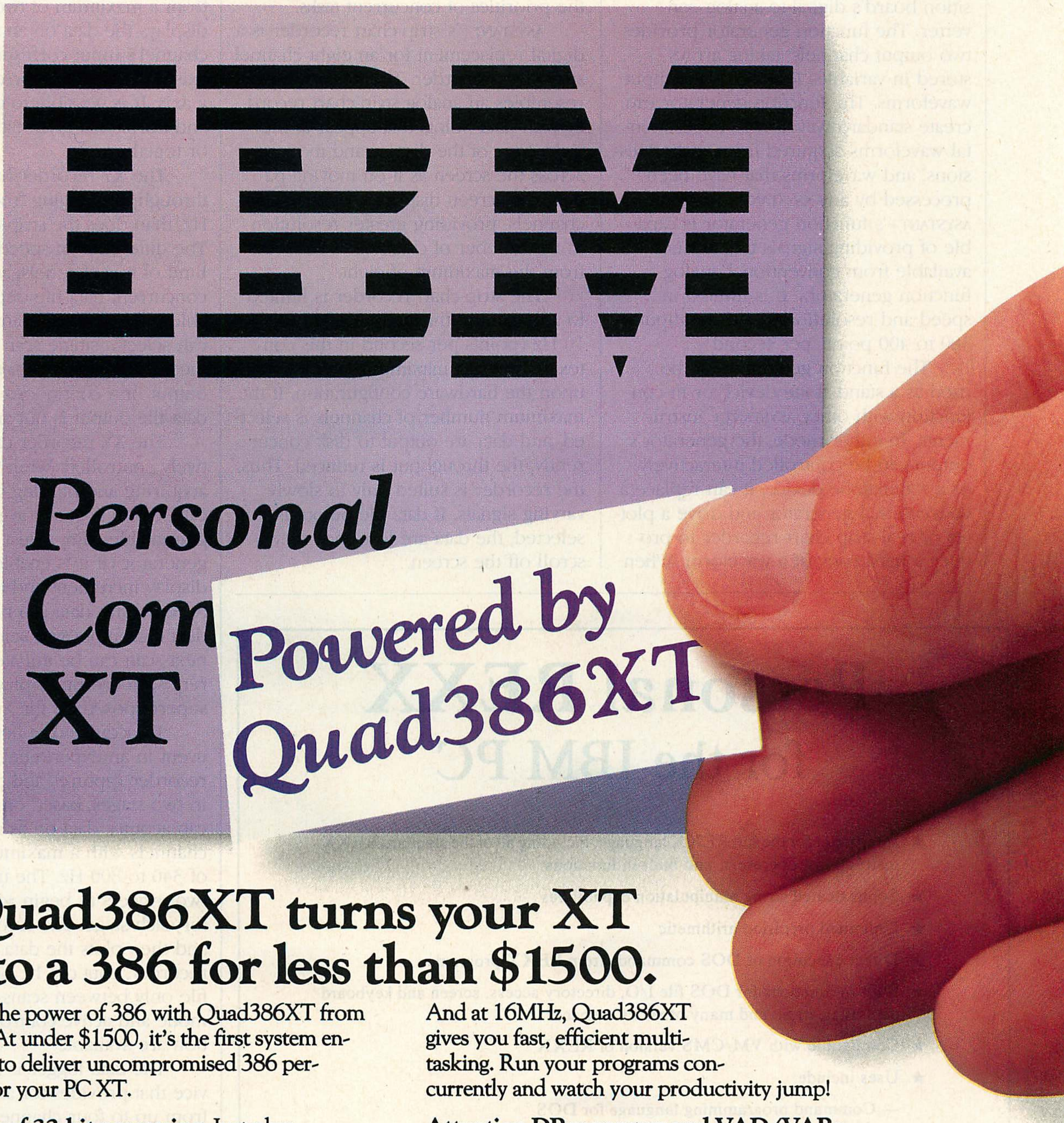

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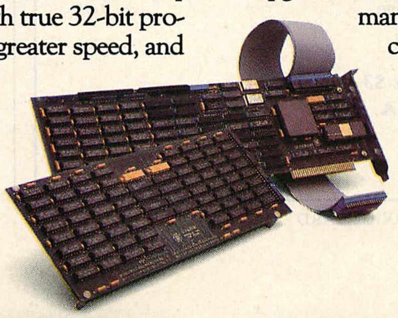

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versely proportional to the number of channels selected.

ASYSTANT+ extends the operation of its waveform generator to the control of the data acquisition hardware, allowing the system to operate as a function generator. The digital values determined by the function generator are used to produce analog signals with the data acquisition board's digital-to-analog converter. The function generator provides two output channels, taking arrays stored in variables *R* and *S* as the input waveforms. The function generator can create standard waveforms, experimental waveforms acquired from earlier sessions, and waveforms that have been processed by any ASYSTANT+ function. ASYSTANT+'s function generator is capable of providing signals that are not available from conventional analog function generators. It is limited in speed and resolution to a throughput of 300 to 400 points per second.

The function generator can be used as a stand-alone device or in conjunction with other ASYSTANT+ instruments. In either mode, the generator's output can be controlled interactively. As a stand-alone device, it can replace a conventional generator and drive a plotter or real-strip chart recorder to produce a hard copy of a waveform. When used in conjunction with the other instruments, the generator can provide a known stimulus or control signal to the experiment. Using the generator with other ASYSTANT+ devices can affect the operation of the generator or the other device, reducing the throughput of the acquisition instrument. The program, however, does allow the operator to set the priorities of concurrent tasks.

ASYSTANT+'s strip-chart recorder is a digital replacement for an eight channel strip-chart recorder. The screen display resembles an analog strip-chart recorder with data points that appear at the right edge of the display and move across the screen as if on moving paper. The screen displays only the active channels, providing greater resolution as the number of channels is reduced from the maximum of eight.

The strip-chart recorder is limited to a maximum throughput of 40 to 70 Hz (points per second in this context), the exact maximum rate depends upon the hardware configuration. If the maximum number of channels is selected, and data are output to disk concurrently, the throughput is reduced. Thus, the recorder is suited only to slowly varying signals. If data file output is not selected, the data are lost once they scroll off the screen.

While it is operating, the strip-chart recorder can be controlled. The data acquisition rate and gain can be altered; data file output can be suspended and resumed; and the display resolution can be modified by skipping data points. If the function generator is active, it may also be adjusted.

The XY recorder acquires data from a maximum of two channels and displays the data on an *xy* plot—one channel's input corresponding to the *x* axis and the other corresponding to the *y* axis. It is possible to display vertical and horizontal grids either individually or together.

The XY recorder has a higher throughput, ranging from 340 to 670 Hz, than does the strip-chart recorder. The difference in speed is due to the limit of two channels, and to a lack of concurrent data file output that is available only between scan cycles. The user can select a single scan mode in which the recorder pauses to allow data file output or a continuous scan in which data file output is not an option.

The XY recorder can be interactively controlled. While the recorder is acquiring and plotting data, the user can set the acquisition rate and programmable gain, adjust the function generator (if it is enabled), change the display increment and halt the scan. Between scans, data can be saved to disk if data file output was selected; then the next scan can be initiated, and the current scan can be displayed versus time, superimposed on the *xy* plot.

To acquire data before and after an event in an experiment, the transient recorder captures and plots analog data in two stages, based on two triggers. It can acquire data on as many as eight channels with a maximum throughput of 340 to 800 Hz. The user must specify two triggers to begin acquisition of data for each stage. The recorder acquires and then plots the data. As with the XY recorder, data can be output to a disk file only between scans. A continuous mode and active control during operation are available.

The data logger is a low-speed device that provides for analog data input from up to four channels and the control of eight digital lines. Its throughput is limited to 1 Hz. However, concurrent data file output, realtime conversion of voltage to engineering units, and simultaneous hard-copy output are available. Data are displayed in text form on the screen in realtime.

Setting the acquisition parameters for the data logger requires three screens instead of the usual one for se-

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AN ELECTRONIC DETECTIVE

In a practical application, ASYSTANT+ can be used as a sophisticated detective in an industrial plant. As an example, a plant engineer installs a tachometer on a component of a production line, and it produces a clean, square wave. However, when the tachometer is connected to the control panel several hundred yards away, the control panel display is greatly altered and meaningless. The plant engineer connects a microcomputer with a data acquisition board and ASYSTANT+ installed, and finds a signal like the one shown in figure 1, instead of the square wave.

The plant engineer then takes the ASYSTANT+ equipped microcomputer to the tachometer and measures the signal directly. As expected, its output is normal, the square wave shown in figure 2. Evidently, the signal is being degraded between the tachometer and the control panel. Because the line from the tachometer to the control room is routed through the plant, past various machines and switchgear, the plant engineer is not surprised. The problem is to identify the offending signals and their sources.

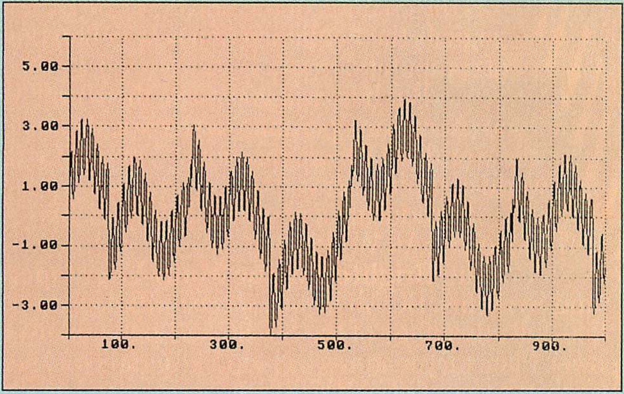
With the noisy signal at the control panel and the square wave sampled at the tachometer stored in ASYSTANT+ variables, the engineer is ready to begin analyzing the signal. After verifying that the square wave and the noisy signal samples represent the same time interval and the same number of data points, the engineer subtracts the square wave from the composite signal. Subtracting the two arrays stored in the variables from each other and storing the result in another variable leaves just the noise that is picked up in the system. The resulting waveform, plotted in figure 3, is still made up of several components.

On a logical hunch, the plant engineer tries subtracting a 60 Hz sine wave, to remove any "power hum". After a few attempts with the waveform processor to get the correct amplitude, the waveform of figure 4 results.

At this point, two components are clearly discernible, a high frequency sine wave riding on a lower frequency sine wave. The frequency of each waveform is easily determined, at least in this simplified example. With the frequencies of these components known, the engineer can set about locating their sources. For a more complicated situation, other methods such as plotting the power spectrum can be used.

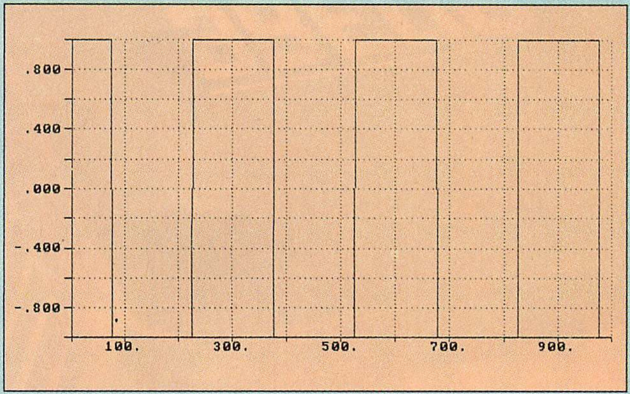
—Victor E. Wright

FIGURE 1: *Waveform at Control Panel*



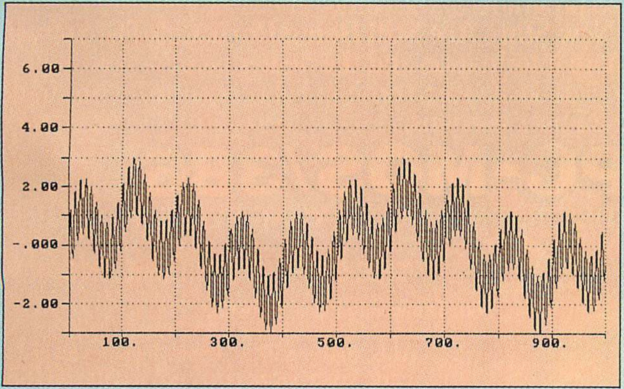
The waveform at the control panel has a large amount of noise superimposed on the square wave.

FIGURE 2: *Tachometer Output*



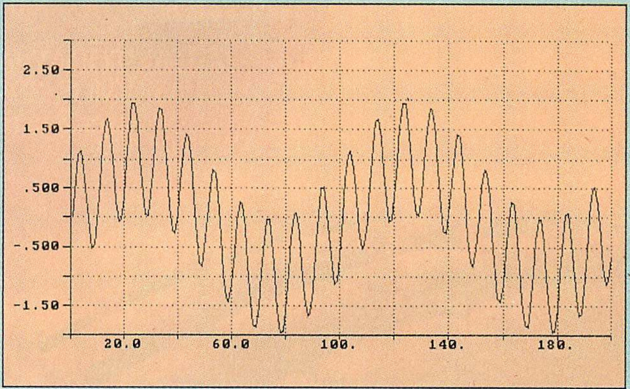
The waveform that is produced at the tachometer end of the signal lines is in the form of a clean square wave.

FIGURE 3: *Noise Waveform*



Subtracting the square wave from the waveform in figure 1 shows the noise that has been inducted in the cables.

FIGURE 4: *Remnant Noise*



After the removal of the power hum, the remnant noise can be seen to be two waveforms, as shown in this example.

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lecting and configuring the analog input channels. Screens are provided to define from one to four stages and up to six alarm triggers. The stages allow the acquisition rate and control logic to be varied during the course of an experiment. The alarm triggers control the display of messages and output of user-defined bit patterns on the digital lines according to analog input levels or digital input bit patterns.

The ability to place bit patterns on the digital port allows the data logger to be used as a controller. It can monitor and display up to four process variables measured with analog sensors, and it can monitor the states of as many as eight digital, two-position, devices. Based on these conditions, the data logger can provide an eight-bit digital output, which can be used to control eight digital devices or, if suitably converted, an analog device. It cannot directly control a proportional control device.

The high-speed recorder provides the highest sampling rate of the ASYSTANT+ instruments, matched only by the signal averager. Depending upon the data acquisition hardware, the sampling rate may exceed 30 KHz. The sampling rate that is realized is affected by the number of channels specified, as well as by the add-on hardware limitations.

This high-speed recorder performs its tasks sequentially, first acquiring the data, then plotting them on the screen, and finally recording them to disk. Users can disable the screen display to reduce the time between scans. Active control is provided, allowing the data plot to be examined in detail between each of the scans.

The signal averager is similar to the high-speed recorder, offering the same sampling rate and number of channels and storing a cumulative average of multiple scans. It allows data file output only at the end of a session, at which point it stores the current cumlative average. The display is similar to that of the high-speed recorder, however, it shows the current scan and the cumulative average scan superimposed for each channel.

HARDWARE CONSIDERATIONS

ASYSTANT+ runs on the IBM PC family of computers, as well as on compatibles. The full 640KB of RAM supported by PC-DOS must be installed, along with an 8087 or 80287 math coprocessor, two diskette drives or one diskette and one hard-disk drive, and a supported graphics board. Supported graphics boards include the IBM Color Graphics Adapter (CGA), the IBM EGA, the Hercules Graphics Card, the AT&T High-Resolution card, and the HP Vectra Multimode adapter.

The program performs the basic ASYSTANT tasks without installing additional hardware. However, if data acquisition is to be performed, ASYSTANT+ does require that a data acquisition board or external data acquisition chassis be used. Supported data acquisition hardware includes the Cyborg Issac 91-I, the Dataq WFS-200PC Waveform Scroller, Data Translation's DT2800 series, IBM's Data Acquisition and Control Adapter, the Keithley Series 500 system, Metrabyte's DASH-16 board, and Tecmar's Lab Master and Lab Tender boards. (See "Digitizing Analog Data," Eric M. Miller, May 1986, p. 52 for reviews of some of these products.)

ASYSTANT+ is a demanding program. In addition to installing 640KB of RAM, the user must ensure that the maximum amount of RAM is available. TSR (terminate and stay resident) programs and device drivers must be kept to a minimum; the safest course is to use only the standard DOS configuration.

For this article, ASYSTANT+ was tested on a Heathkit H-241 AT-compatible computer, with 640KB of RAM, 2,176KB of extended memory, an 80287 numeric coprocessor, a Concept Technologies ConceptBoard graphics adapter, and a Data Translation DT2801A data acquisition board.

Although ASYSTANT+ can operate on a dual-diskette system, a hard disk should be considered a practical requirement. Macmillan furnishes ASYSTANT+ on six diskettes—running the program from diskette drives requires frequent swapping of diskettes and severely limits file storage.

Program configuration is an option when the program is first loaded. The program displays a sign-on message and then a menu with options to recall functions, parameters, and variables from a disk file, to perform hardware configuration, and to begin using the program. The second selection, **Setup**, displays a configure menu, with options for selecting the display, plotter, and printer, and for disk assignments for the system overlay, data, and help files. The initial installation of the program consists of copying the files from the distribution disks. Configuration is accomplished at the beginning of the initial session and can be repeated at the beginning of any subsequent session.

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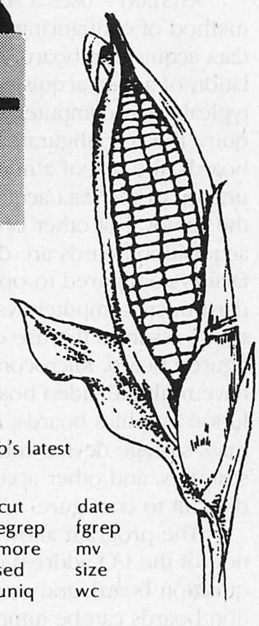

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ASYSTANT+ uses a straightforward method of configuring and controlling a data acquisition board. However, installation of a data acquisition board in a typical microcomputer system may require the reconfiguration of other boards, the use of a nonstandard configuration of the data acquisition board, or the removal of other boards. Most data acquisition boards are designed and factory-configured to operate in a standard microcomputer system, and ASYSTANT+ assumes the use of a factory-configured board. Microcomputers that have multiple video boards, high-resolution graphics boards, nonstandard mass storage device controllers, mice scanners, and other accessories may be difficult to configure.

The program allows the specification of the I/O address of the data acquisition board, and most data acquisition boards can be jumpered to one of several addresses. Selecting an unused I/O address in a complex system may not be trivial, but it can be accomplished with some research.

To provide high-performance hardware, many data acquisition board companies incorporate circuitry to use the computer's DMA channels, as do the manufacturers of hard-disk controllers, tape backup systems, optical scanners, network interface boards, and other high-performance accessories. The standard PC has four DMA channels, two of which are free for accessories; the XT has only one free channel to support all of the accessories that require DMA services. ASYSTANT+ does not use DMA, but some acquisition boards must be configured to use DMA. The user must pay attention to this issue.

Some data acquisition boards implement a memory mapped addressing scheme rather than an I/O addressing scheme, using the memory above the base 640KB of user RAM. These boards, designed when it appeared that there were "holes" in the PC's memory map, may conflict with the EGA and other video boards or with other accessories that use normally vacant segments of the memory map.

RATING THE PERFORMANCE

As a calculator, ASYSTANT+ is a high-performance program. Most computational tasks, including matrix operations, are performed almost instantaneously. A few of the advanced operations are slower, but still reasonably fast, requiring a few seconds at most.

As a data acquisition system, ASYSTANT+ realizes the potential of the microcomputer. Critical elements of the program are written in assembly language to attain the highest possible speed of operation. However, a microcomputer is limited by its design as a general purpose computing machine. Overall system throughput is limited by the speed of the data acquisition board, the clock speed of the computer, and the speed with which data can be written to disk. ASYSTANT+ achieves its ultimate performance, which is essentially the performance limit of the data acquisition accessory, by dedicating the host computer to controlling the accessory and transferring the acquired data to RAM. Graphic displays and disk I/O are performed between acquisition tasks.

ASYSTANT+, a data acquisition board, and a microcomputer will not replace a battery of high-performance, dedicated laboratory instruments. Dedicated instruments are able to offer higher sampling rates, sometimes by factors of hundreds or thousands, than does an ASYSTANT+ data acquisition system. Furthermore, they provide higher accuracy and resolution. As an example, an HP 3852S Data Acquisition and Control System, suitably configured, can acquire 100,000 readings per second and store up to the order of 64,000 readings locally. High-performance digital storage oscilloscopes and waveform analyzers

Thanks for all the cold pizza, drinking diet a 'normal' job.

can acquire data at sampling rates of tens of millions of samples per second. Nevertheless, the ASYSTANT+ based system is a sound solution to the data acquisition problem. An example of ASYSTANT+'s uses is given in the accompanying sidebar.

It should be noted that the basic acquisition and analyzing of data is provided by the data acquisition hardware and not the program. The ambitious experimenter/programmer may be able to do quite well without ASYSTANT+, by writing custom software to control the hardware. But the average experimenter, who must concentrate on the task at hand, will find that ASYSTANT+ makes configuring a comprehensive system a relatively straightforward procedure. Writing custom software to match ASYSTANT+'s analysis and presentation capabilities could not be done within a reasonable timeframe.

THE SOFTWARE PACKAGE

ASYSTANT+ comes with seven diskettes. The program is copy protected; a key diskette must be inserted in a diskette drive to load the program. An alternative to the key diskette arrangement is available from Macmillan in the form of a hardware protection device. All of the software can be copied to the hard disk or to the diskette drive with the DOS COPY command.

The manual is a 2-inch, loose-leaf binder with 8½ by 11-inch pages. It includes a tutorial, a reference section, several appendices, and an index, all separated with tabbed dividers. A hard slipcase is included. Both the printing and packaging are excellent.

The tutorial is thorough and accurate. It guides the user through the essential features of ASYSTANT+. Although the tutorial assumes that the user already has some knowledge of data acquisition, it is suitable for use as a refresher for occasional practitioners, or as an introduction for a determined beginner. The tutorial can be completed in a reasonable amount of time.

The reference section is well organized, closely following the program's menus. It covers the simulated instruments in considerable detail. The user will seldom have to refer to the data acquisition hardware documentation if the hardware is controlled exclusively with ASYSTANT+.

One possible drawback is that the manual is definitely not a mathematics textbook. The advanced math functions available in the calculator are summarized only briefly. Users who occasionally require Bessel functions and fast Fourier transforms may need to keep an assortment of math textbooks handy. The sister product, ASYST, provides a more insightful tutorial for using the mathematical functions.

ASYSTANT+ adds realtime data acquisition capabilities to the ASYSTANT calculator, which rivals any general purpose computational tool, microcomputer-based or not, in terms of speed, ease of use, and functions. The data acquisition capabilities obviously do not match those of dedicated instruments. However, they do provide a comprehensive assortment of techniques for applications that can tolerate moderate sampling rates and provide these features at much lower cost than dedicated instruments. An ASYSTANT+ system is a well-balanced solution to moderate data acquisition needs and a high-performance solution to analysis needs.

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Victor E. Wright is the manager of process engineering at Luckett & Farley, located in Louisville, Kentucky.

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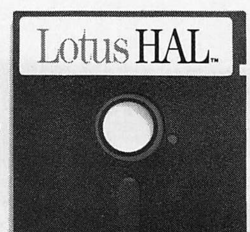

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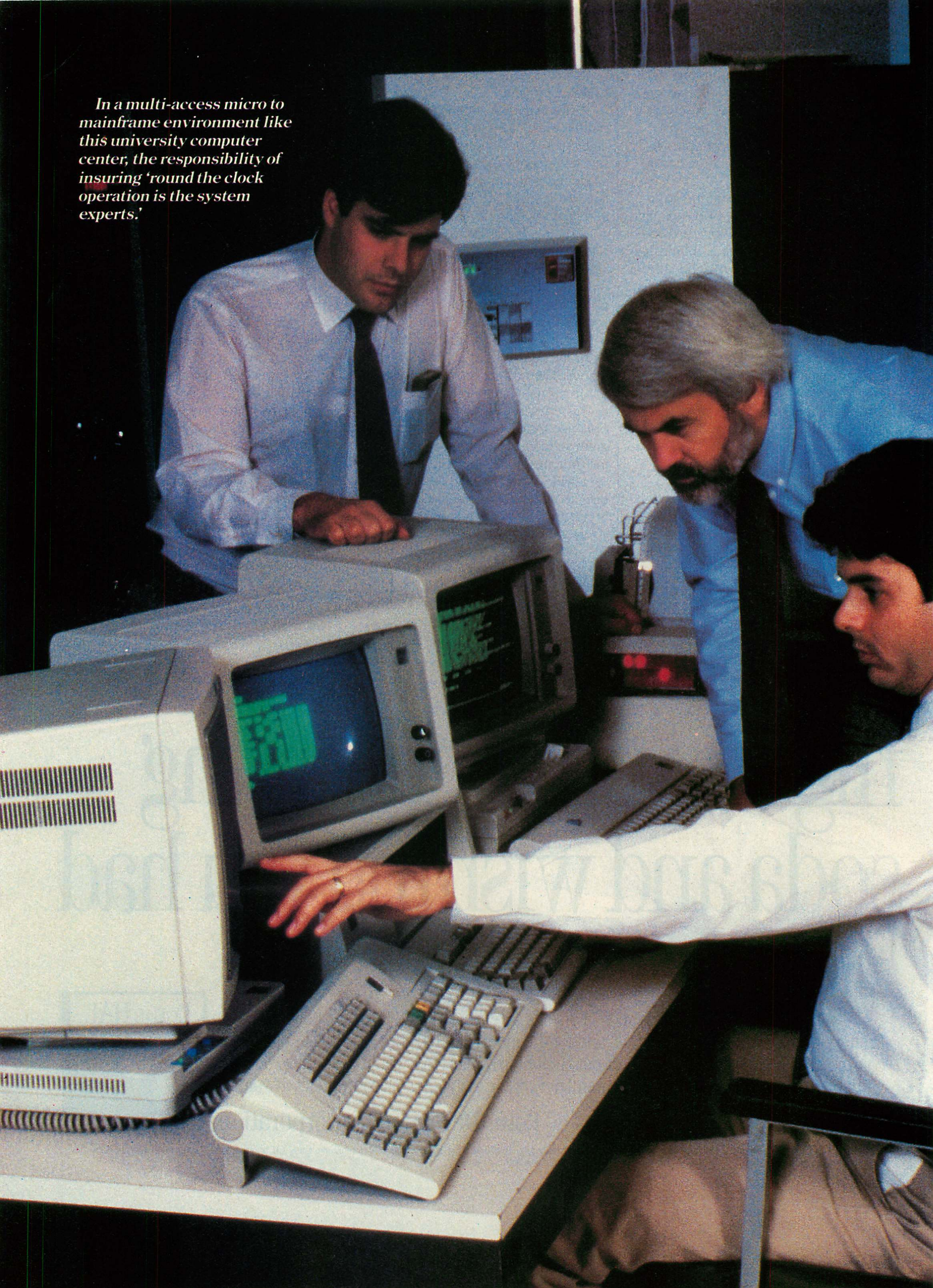

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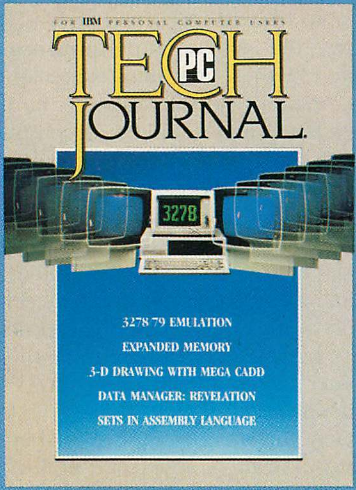

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Speed Infusion

The original IBM PC, which seems slow compared with 80286 machines, can be speeded up with different types of accelerators; these six do so by increasing the clock speed of the PC's resident 8088.

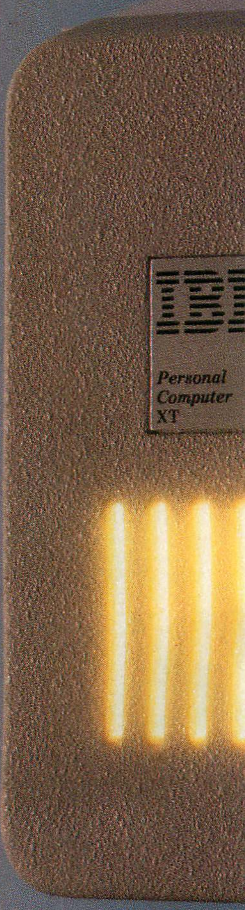
TED MIRECKI

Speed is much of what computers are all about. As each new category of personal computer is introduced, it necessarily boasts a higher clock rate: the original 4.77-MHz IBM PC was followed by 80286 machines running first at 6 MHz, then at 8, 10, 12, and now 16 MHz. The new 80386 models start at 16 MHz, but have the potential to reach 24 MHz and beyond. Moreover, the increase in performance delivered by these machines is greater than the ratio of clock frequencies because the amount of work they accomplish at each clock cycle is much greater. By comparison, the PC is slow indeed.

Rather than putting up with a sluggish machine or replacing it outright, the hapless PC user has one other option: a PC accelerator board. Accelerators work by adjusting one or both of the parameters that determine the computer's internal processing speed: they modify either the clock rate (the frequency at which computational events occur) or the amount of useful work performed at each event, or clock cycle. Increasing the clock rate would seem to be a fairly simple process, but it is far from trivial on the PC. And expanding the processing power is more complicated still, requiring the replacement of the PC's 8088 with something more capable, such as an 8086, 80286, or 80386.

This article reviews accelerator boards referred to here as Class I: they run the PC at a higher clock speed but retain the 8088 (or, in some cases, upgrade to an NEC V20). Six products are evaluated: American Computer & Peripheral's American Turbo, Maynard Electronics' Surprise!, Megahertz Corporation's TurboSwitch, Microspeed's Fast88, Microsync's Screamer, and MicroWay's 87/88 Turbo. Articles in subsequent issues will deal with boards in Classes II and III, which are more complex boards that contain advanced microprocessors with data paths that are wider than eight bits.

Because these first boards are, for the most part, simple devices, the performance improvement they deliver is far from spectacular. Still, their rela-



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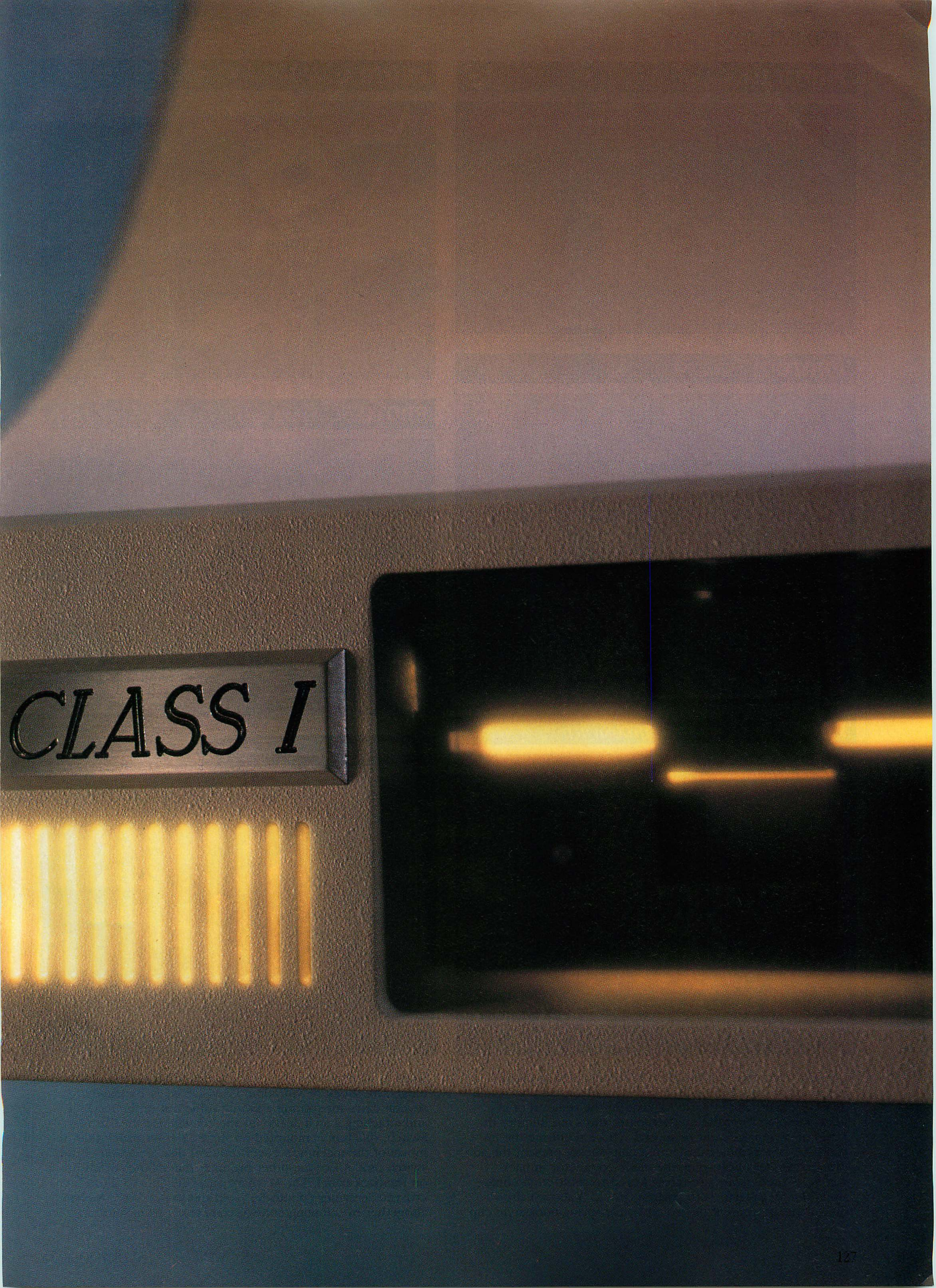

CLASS I

PHOTO 1: *American Turbo*

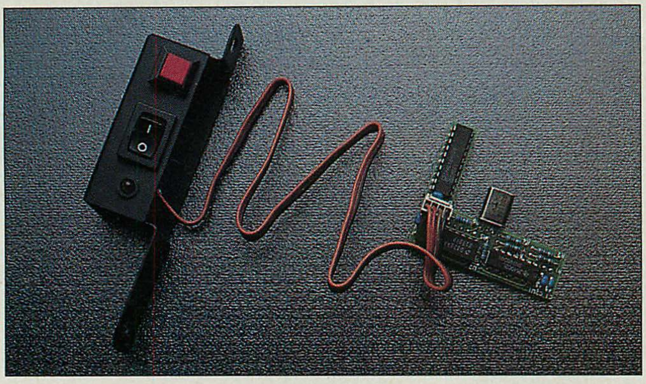


PHOTO 2: *Maynard Surprise!*

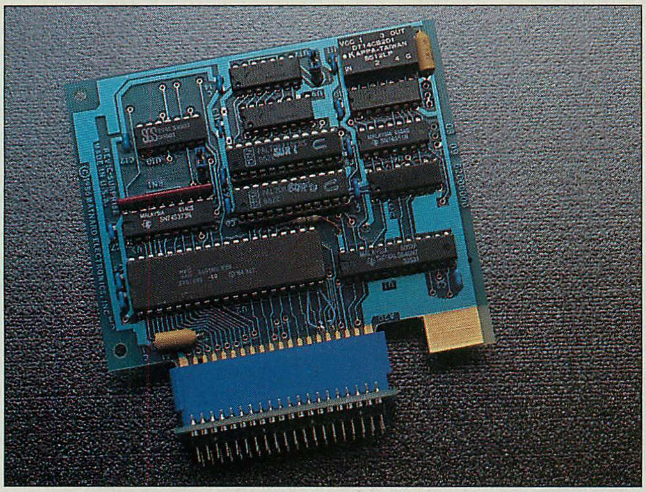


PHOTO 3: *Megahertz TurboSwitch*

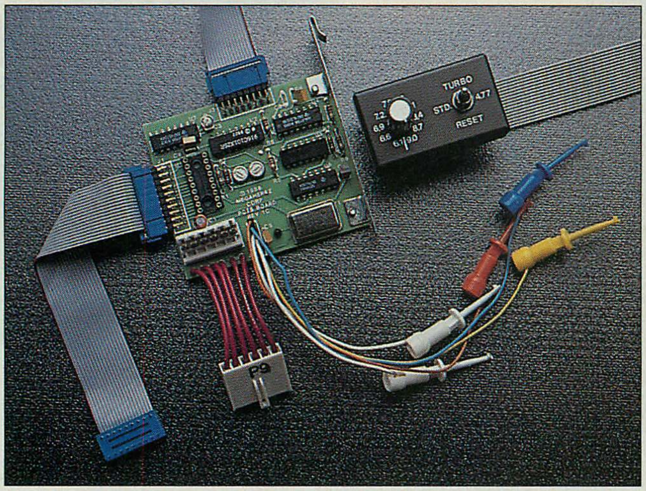


PHOTO 4: *Microspeed Fast88*

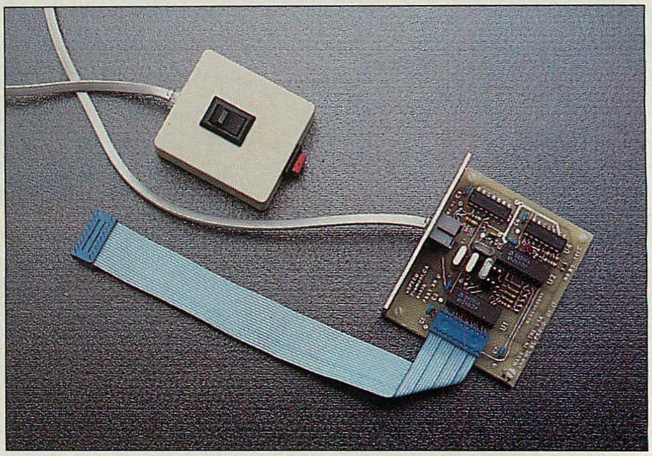


PHOTO 5: *Microsync Screamer*

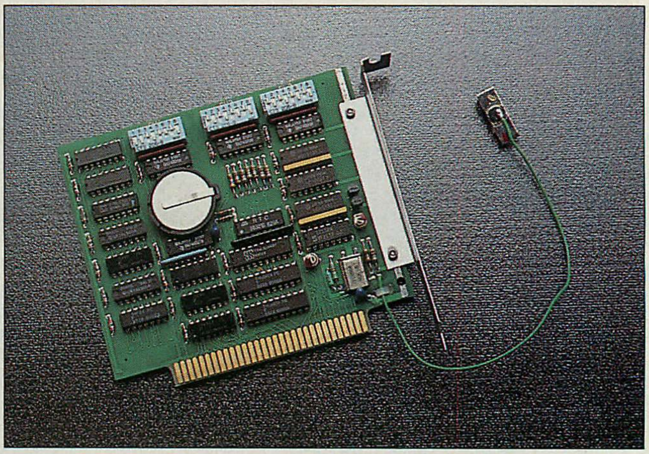
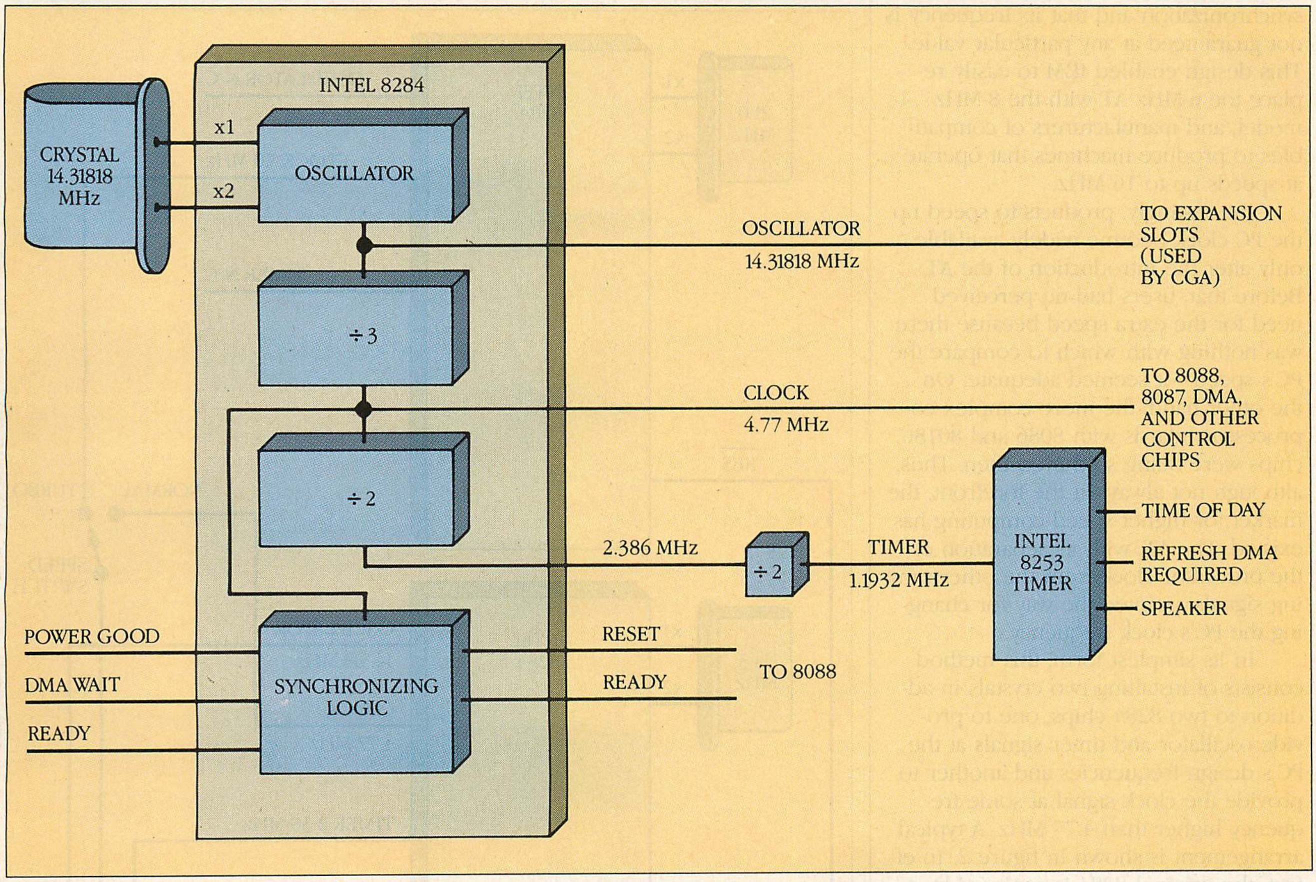


PHOTO 6: *MicroWay 87/88 Turbo*

Because each product modifies PC timing circuits (which were not designed to be modified), none is as easy to install as a typical PC add-in card. All require the removal of at least one chip from the motherboard, and some require the removal or replacement of several. Those requiring the installation of a ribbon cable into a chip socket present the additional danger of plugging the cable connector in backwards, as such cables are rarely keyed to avoid such confusion. The Megahertz TurboSwitch (photo 3 above) also requires the attachment of several fragile spring-hook-style clip leads to chip pins on the motherboard. These are easily dislodged by shock or vibration. Provision must be made in several cases for routing a switch cable out of the machine and attaching a switch box to the chassis. For the TurboSwitch, this box is mounted on the PC's front panel; thus, removal of the machine's cover requires disconnection of the switch box. All of the other products mount the switch box on the back panel. The Maynard Surprise! (photo 2) and Microsync Screamer (photo 5) avoid the switch box problem altogether by allowing control completely from software.

PHOTOGRAPHS • BLAKESLEE/LANE

FIGURE 1: *The PC/XT Clock Generator*



The oscillator and timer frequency cannot be altered without disrupting system operation. The oscillator signal is essential to 200-line video modes, and the timer signal generates the 55-ms time-of-day interrupt and controls dynamic RAM refresh.

tively modest price (starting at about $100) makes the purchase of one a worthwhile investment. An understanding of how they work also provides some interesting insights into very fundamental aspects of the PC's design.

IS TIMING EVERYTHING?

The main clock frequency that drives all PC system components is derived from a quartz crystal. In theory, a higher frequency can be obtained by changing this part. However, such an operation carries intrinsic difficulties. First, the crystal is soldered to the motherboard—its removal is no small task. A more serious problem is that this one source provides a base for several different frequencies used in various parts of the computer. As figure 1 shows, an Intel 8284 clock generator produces various timing signals from one crystal frequency. In a stock PC, these signals are for the following components.

The oscillator has a frequency that is equal to the crystal's resonant frequency of 14.31818 MHz. This frequency is fed to the expansion slots and used by various adapter cards, most notably the IBM Color Graphics Adapter (CGA), which divides it by 4 to obtain the 3.58-MHz color burst frequency required by television monitors.

The main processor clock runs at 4.77 MHz, a speed obtained by dividing the oscillator frequency by 3. This is the heartbeat of the computer, the signal that synchronizes all activity in the system. At each beat of the clock, adders add, shifters shift, buses transmit, and so on. The duration of one clock cycle (the clock period) is the reciprocal of the frequency, or 210 nanoseconds (ns).

The timer is a 1.1932-MHz signal obtained by dividing the clock frequency by 4 (actually, the 8284 outputs a signal that is the clock's signal divided by 2; this is again divided by 2 by circuitry on the motherboard). This timer signal is used by the 8253 timer chip in three timers, each of which may be programmed to produce different frequencies by various divisions of the input. The first timer channel runs at 18.2 Hz (timer signal divided by 65,536) and produces the familiar timer-tick interrupt every 55 milliseconds (ms) that maintains the time-of-day clock. The second channel runs at 66.3 KHz (input divided by 18), generating a DMA (direct memory access) request for dynamic memory refresh every 15 microseconds (μs). Both of these timers are initialized by the ROM boot-up routines. The last timer channel controls the speaker; its divisor can be set by a user program to any value between 1 and 65,536, thereby theoretically producing sounds from the ultrasonic down to 18 Hz. In practice, the physical limitations of the speaker limit it to a much narrower range of about 100 Hz to 8 KHz.

Simply changing the crystal frequency, therefore, is not a possibility. The realtime clock, CGA video synchronization, and, most critical of all, dynamic memory refresh, are all too intimately associated with it. This is not a problem with the AT, in which the processor clock is driven by its own crystal—the AT clock frequency is one-half that of the crystal, not one-third as in the PC—and the oscillator and timer signals are derived from a separate 14.31-MHz crystal. In addition, the crystal driving the clock generator is socketed for easy replacement. The AT doc-

umentation states that the clock signal is located in the expansion slots solely for synchronization and that its frequency is not guaranteed at any particular value. This design enabled IBM to easily replace the 6-MHz AT with the 8-MHz model, and manufacturers of compatibles to produce machines that operate at speeds up to 16 MHz.

Interestingly, products to speed up the PC clock became widely available only after the introduction of the AT. Before that, users had no perceived need for the extra speed because there was nothing with which to compare the PC's speed—it seemed adequate. On the other hand, the more complex coprocessor boards with 8086 and 80186 chips were being sold even then. Thus, although not always at the forefront, the market for higher-speed computing has existed. The AT, with its separation of the processor clock from the other timing signals, pointed the way for changing the PC's clock frequency.

In its simplest form, this method consists of installing two crystals in addition to two 8284 chips, one to provide oscillator and timer signals at the PC's design frequencies and another to provide the clock signal at some frequency higher than 4.77 MHz. A typical arrangement is shown in figure 2. In effect, the original 8284 is replaced by a printed circuit board (PCB) containing two 8284s; the various signals from the two are fed to the motherboard via the PC's original original 8284 socket. This requires that the original 8284 be mounted in a socket. Some machines arrive with the 8284 soldered; in this case, it must be desoldered and a socket installed. Fortunately, the 8284 is socketed in most IBM PC's.

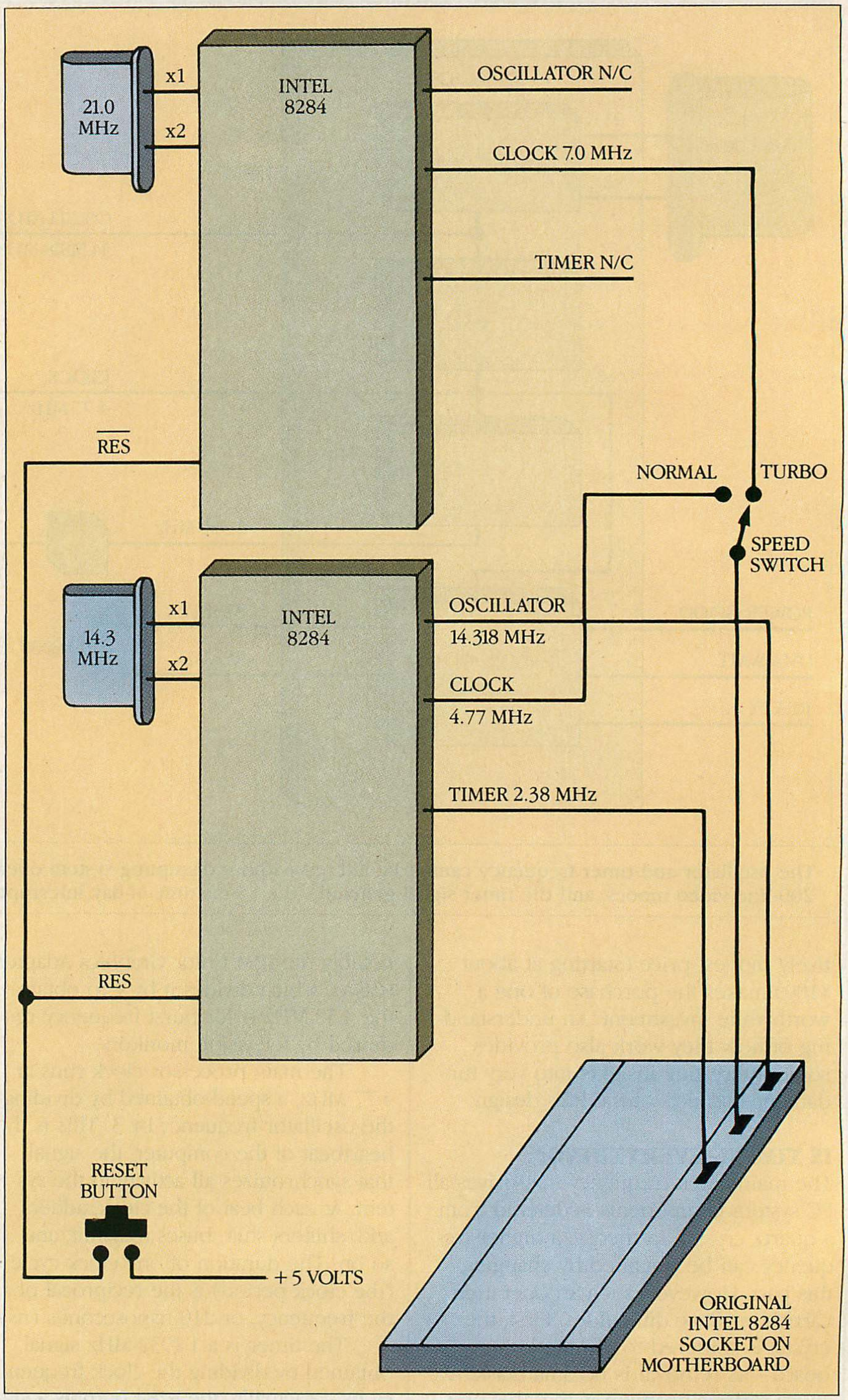
Figure 2 also demonstrates how the replacement of the 8284 with this additional circuitry permits the implementation of two switches. One switch is used to move between 4.77-MHz mode and high-speed (*turbo*) mode. This is useful for clock-sensitive software, such as copy-protected programs, that does not work at high speed.

The second switch really should have been a part of the original PC design; it is a hardware reset that performs a cold boot in the same manner as the power switch, but with less wear and tear on the circuitry (especially hard disks). An explanation of how this reset is accomplished, and the ways in which it differs from a keyboard reset, is provided in the sidebar, "Alternatives to the Big Red Switch," p. 135.

Therefore, the PC's pulse can be quickened without disrupting the activities that depend on a fixed time period. The next question is, can the hardware components in the PC keep pace with the faster clock? The most critical of these is the microprocessor, which typically is not capable of running at much beyond its design rate. In a stock PC, the 8088 is rated at 5 MHz and cannot be speeded up by a significant percentage. It can, however, be replaced easily and at a reasonable price (even for a very high-speed chip). All of the boards reviewed here incorporate a high-speed replacement microprocessor. Again, this requires that the CPU be socketed.

With a faster processor, the clock rate can be increased until the next bottleneck is reached; in most cases, this

FIGURE 2: *A High-speed Replacement Clock Generator*



The 8284 running at 21 MHz is used only to generate a 7-MHz clock signal. The slower 8284 generates oscillator and timer signals at standard PC/XT frequencies.

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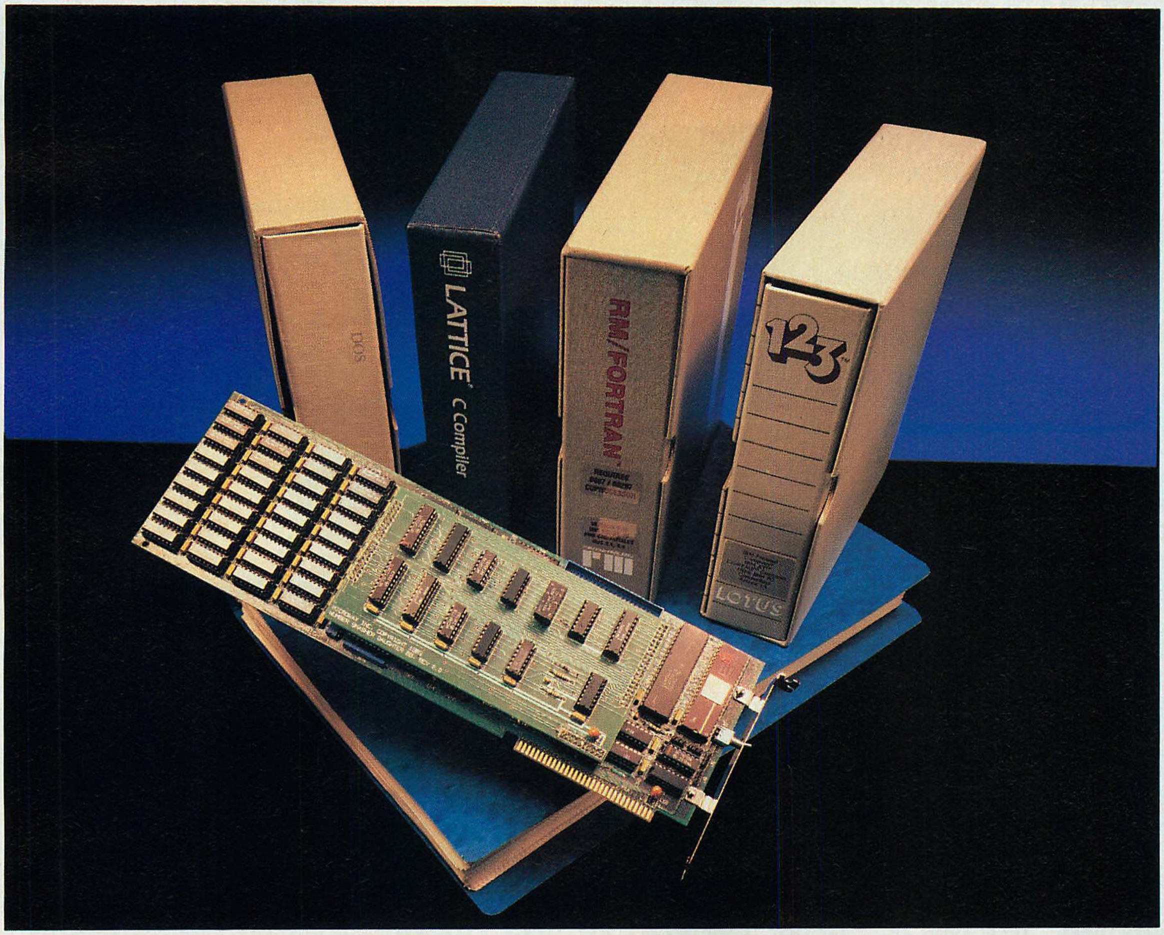

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turns out to be the response time of the memory chips. However, some other chip, the DMA chip or interrupt controller, for example, may be the limiting factor. If speed is limited by memory, it might be practical to replace the entire complement of RAM chips with higher-speed chips. Note, however, that the first bank of memory is usually soldered to the motherboard. It is one thing to replace a single 8284 chip with a socket; it is quite another to do likewise for eight additional chips. Therefore, except for the faster CPU they bring, most clock accelerators are designed to stay within the limits of the machine's original components.

The most obvious way to accomplish this is to limit the new clock frequency to a rate acceptable to the slowest component in the system. To do so and still manage to realize speed improvement can be attributed to two factors: first, components usually are specified slightly faster than they need to be, and second, each component typically exceeds its specifications slightly. The additive effect of these factors can be sufficient to allow a 50-percent increase in the clock rate. The simpler clock accelerators, those providing circuitry not much more complex than that shown in figure 2, follow this approach.

Another method of circumventing speed limitations is to provide hardware that slows the system down as required, either by changing to a slower clock rate at critical times or by allowing more clock cycles for certain activities. The latter involves the insertion of *wait states*—extra clock cycles—into the memory I/O cycle (see "The Bottleneck at the Display Adapter," Michael Abrash, January 1987, p. 104). Wait states in AT-class machines are a hot topic, but the same considerations must be given the PC. The action and role of the wait state is tied to the manner in which data transfers occur between the CPU and memory or I/O ports.

WAIT STATES

In general terms, the time needed to transfer one unit of data to or from the CPU is called a *bus cycle*. In the 8088, the unit of data is one byte, and the minimum length of a bus cycle is four clock cycles. These cycles are designated T1 through T4. Each cycle encompasses specialized activities.

During T1, the CPU outputs a bus transfer request on its status lines and an address on its data/address lines. The status lines indicate the type of access, either to memory or to an I/O port, and whether it is to read or write. The bus controller saves the address in an address latch so that it is available during the remainder of the bus cycle.

In T2, the CPU removes the address from the data/address lines and, for a write request, places the output data there. For a read request, the lines are disconnected from the CPU to make them available to the memory or I/O device that will supply the data. The use of the same lines for different information at different times is known as *time multiplexing*. This allows the complex signal requirements of the 8088 to be accommodated by a relatively compact 40-pin package. Meanwhile, address decoding circuits connect the data lines to the proper memory chips or I/O ports, and data transceivers establish the signals that control the direction of the transfer (to or from the CPU).

During T3, the memory or I/O device performs the actual transfer, while the CPU does nothing. In the last cycle, T4, the device disconnects itself from the data lines and disables all of its control signals, returning to a quiescent state. For a read, the CPU recon-

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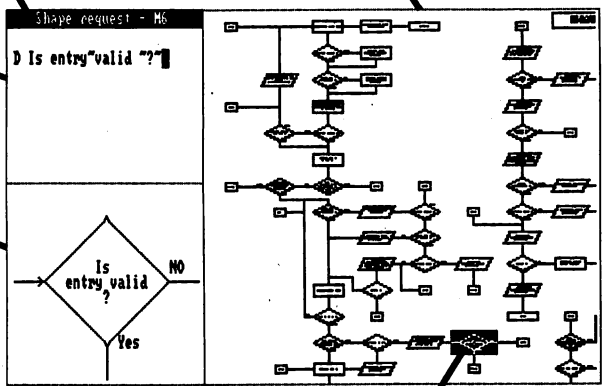

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nects itself to the data lines and then can use the data it finds there.

This four-step process represents a minimum bus cycle with zero wait states. Nominally, the time for transferring data to or from devices is one clock cycle; at 4.77 MHz, that time is 210 ns. By no coincidence, the memory chips in the PC have a cycle time of 200 ns. Actually, the time available for the transfer is a little longer, because an addressed memory chip becomes active towards the end of T2 and need not complete the transfer until sometime after the start of T4. (Early PCs worked fine with 250-ns chips; the switch to 200-ns devices was not made out of necessity, but because of the increasing availability of the faster chips. For similar reasons, the latest models have the readily available 150-ns chips.)

If a memory chip or I/O port cannot respond quickly enough to transmit data in the one-and-a-fraction clock cycles, it can be designed to insert wait states between T3 and T4. The mechanism used to insert these is the READY line of the CPU. During a bus cycle, the CPU does not enter state T4 unless READY is high. When a slow device is selected by the address decoding logic at T2, it immediately drops READY to low. The signal is fed to the 8088 through the 8284 to synchronize transitions in the READY line with clock cycles. READY has no effect on T3, but thereafter, the CPU will remain idle—that is, in a wait state—for each clock cycle that READY remains low. After some predetermined number of clock cycles passes—sufficient to complete the data transfer—the device raises READY high, allowing the processor to advance to T4 to complete the bus cycle. Figure 3 is a simplified timing diagram for two bus cycles, one with zero wait states, the other with two.

The PC was designed with zero wait states for memory access and one wait state for I/O port access. This one wait state is inserted without regard for the speed of the device being addressed because an I/O access cannot be completed in less than five clock cycles (1,050 ns at 4.77 MHz). However, a slow device can insert additional wait states if necessary. Similarly, a memory expansion board can be designed to insert a wait state whenever memory on that board is accessed. None of the regular boards is designed this way, although some expanded memory boards do insert wait states.

By comparison, the bus cycle of an 80286 is two clock cycles, but a standard AT inserts one wait state into each

ALTERNATIVES TO THE BIG RED SWITCH

The hardware design of the IBM PC omits one feature that typically is part of every computer: a reset button. The big red switch at the right rear is not an appropriate alternate, for reasons quite apart from its inconvenient location. It takes 10 to 15 seconds after being switched off for the power supply to bring its output to zero volts before the system will restart. More importantly, power-downs and power-ups put undue strain on the electronic and mechanical components, especially hard disks. The Ctrl-Alt-Del keyboard combination is not adequate because, as every PC user knows, it fails at times when a reset is most necessary—to resurrect a crashed system.

Many PC clock accelerators rectify this situation by providing a hardware reset switch. The reset is associated with the clock circuitry because the 8088 reset signal is controlled by the 8284 clock generator in order to synchronize it with the processor clock: the 8088 needs to be at a predictable point within a clock cycle when it is interrupted and restarted. Ordinarily, the "power good" signal from the PC power supply is tied to the 8088's reset line, making a power-down/power-up cycle the only way to initiate a hardware reset on the PC. As shown in figure 2 of the article, the rerouting of the 8284 inputs and outputs in the accelerator circuit allows rerouting of the 8284's reset line (RES) to a switch that performs a hardware reset (cold boot) without powering down the system.

The operation of the reset signal itself is handled carefully within the PC. The 8088 operates only while the reset line is low (at logic level 0); when reset goes high, the processor stops. On a high-to-low transition of reset, the CS (code segment) register is loaded with FFFFH, all the other registers and flags are cleared to zero, and execution is resumed. The next instruction is fetched from the address pointed to by the CS:IP register pair, thus causing a jump to location FFFF:0H. In the PC, that location is in ROM and contains a jump to the ROM POST (power-on self-test) routine.

In a stock PC, the 8284 reset input is connected only to the power-good signal from the power supply. At power-up, this signal is initially high and is pulled low by the power supply when its output comes up to specification. This causes the processor to begin executing the POST as soon as the power supply has stabilized. If the power should fall outside of specification during operation, the reset line goes high, stopping the system. When and if power is restored, the line again goes low as on power-up. Thus, a power supply with intermittently failing regulation circuits can cause spontaneous reboots.

The keyboard reset is handled entirely by software, not by switching the hardware reset line. The BIOS routine that responds to keyboard interrupts, when it detects this particular combination, executes a jump to the beginning of the POST routine. Before doing so, it sets a flag in the BIOS data area; during POST, the value of this flag determines whether a short or long memory test is performed. If the machine was just turned on, the flag will not have the value (1234H) set by the keyboard routine, and a long memory test is executed.

In most cases, the keyboard reset has the same effect as a hardware reset, except when the system has crashed, meaning that the processor has turned off interrupts and is stuck executing some infinite loop. At such times, keyboard input is unrecognized because the keyboard interrupt service routine has no way to gain control, examine, or respond to the signals sent by the keyboard controller.

But even when a system is up and running, other situations can hinder a keyboard from producing a reset. The BIOS keyboard routine may have been replaced by another program installed as a device driver or a resident utility, and this new program might take some action other than reset upon detecting the Ctrl-Alt-Del combination. For example, under DESQview (by Quarterdeck Office Systems), a keyboard reset closes only the current window and does nothing if no windows are open. Other resident programs that perform nonstandard functions with Ctrl-Alt-Del can reassign the reset function to some other combination of keys.

A final subtle difference between hardware and keyboard resets is that at the start of the latter, interrupts are not disabled. A hardware reset, by contrast, zeroes out all flags, including the interrupt-enable flag. This is essential at power-up, so that interrupts are held off until the interrupt vector table is initialized and the interrupt service routines are loaded. It is possible, if not probable, that between the time Ctrl-Alt-Del is recognized and the POST gains control (it begins with an instruction to disable interrupts), a hardware interrupt diverts control for some finite time. Even if control eventually reaches the POST, the point is that the response time to a keyboard reset cannot be guaranteed.

A hardware reset switch thus offers the best of all worlds: it is guaranteed to work predictably in all situations short of physical failure in the circuits, and it avoids the stresses of powering up. But does the switch produce a short reboot, like a keyboard reset does, or a long one, such as at power-up? The POST performs short or long diagnostics depending upon the value it finds in the BIOS reset flag; at the end of POST, the value is not changed. Therefore, if the reset switch is pressed after a keyboard reset, the POST finds the keyboard reset value in the flag and performs a short test sequence. If the previous POST was a long one initiated by power-on, the next one caused by pressing the reset switch will take just as long.

To ensure that the reset switch always performs a short reboot, the reset flag can be set to the proper value upon boot-up by a program from the AUTOEXEC.BAT file. SET1234.COM is created with DEBUG as follows:

```
DEBUG SET1234.COM
                    (Ignore "not found")
A
MOV   AX,40
MOV   DS, AX
MOV   WORD PTR [72],1234
INT   20
                    (Press Return)
R     CX
D
W
Q
```

Alternatively, the flag may be set by running the following BASIC program:

```
10 DEF SEG = &H40 : POKE &H72,&H1234
```

Thus, the reset function provided by clock accelerators is a welcome fringe benefit to their primary function. After using one of these, it is even more frustrating than usual to have to reach for that big red switch.

—Ted Mirecki

TABLE 1: *Features Comparison*

	AMERICAN COMPUTER	MAYNARD ELECTRONICS	MEGAHERTZ CORPORATION	MICROSPEED	MICROSYNC	MICROWAY
MODEL	American Turbo	Surprise!	TurboSwitch	Fast88	Screamer	87/88 Turbo
PRICE	$120.00	$249.00	$149.95	$149.00	$199.00	$149.00
MICROPROCESSOR	8088-2	V20	8088-2	8088-2	V20	V20
CLOCK SPEEDS (MHz)	7.37	9.55	5.96 to 8.79	6.14, 6.67, 7.37	6.00, 8.00	6.67, 7.37, 8.00
SPEED CHANGE BY						
Switch	●	○	●	●	○	●
Hot key	○	●	○	○	●	●
Program	○	●	○	○	●	●
RESET SWITCH	●	○	●	●	○	●
CLOCK/CALENDAR	○	○	○	○	●	●
TAKES UP A SLOT	○	○	○	○	●	●
I/O PORTS USED	None	2E8H-2EFH 2C8H-2CFH	None	None	2C0H-2C2H	280H-288H 2A0H-2A4H

● = *Yes* ○ = *No*

While many of the PC compatibles with fully socketed memory can be made to run at speeds up to 8 Mhz, the original IBM PC contains at least one soldered row of slower memory chips and usually cannot be made to run faster than 6.5 or 7 MHz. At those speeds, the performance enhancement achieved is not always worth the expense and difficulty of installation.

memory access and at least four wait states into I/O accesses. At 6 MHz, an I/O access takes 1,000 ns (6 clock cycles of 167 ns each), or about the same total time as an I/O cycle on a PC. This ensures that PC peripherals are usable on the AT. (The issue of wait states in 80286 memory bus cycles will be covered in a subsequent article.)

SWITCHING TO SPEED

Varying the clock frequency and inserting wait states can be accomplished only by accelerator boards that contain more complicated circuitry than the simple clock replacement arrangement shown in figure 2. Of the six products tested here, only the Surprise! board is sufficiently intricate. The PC TurboSwitch and the Screamer switch automatically to slower clock frequencies under certain circumstances. The others take their chances with the pushing of the PC's components beyond specification. Most provide a choice of several clock speeds so that more capable machines need not be limited to the lowest common denominator.

Table 1 is a features comparison of the six boards reviewed. Each board was tested in two different systems. The first was an IBM PC-2 with 640KB of memory, a 2MB AST RAMpage! expanded memory board (384KB of this was back-filled conventional memory), two diskette drives, a Seagate ST225 20MB hard-disk drive with Xebec combination diskette/hard-disk controller, and an IBM CGA. Conventional memory consisted of a mixture of 200-ns and 150-ns chips; expanded memory was 256K-bit, 150-ns chips. This system's maximum clock rate was about 7 MHz; the rate was not improved by removing the expanded memory board.

The second system tested was a PC/XT compatible with 8-MHz turbo capability. On this system, the performance delivered by the accelerator boards was less than that from switching to its native 8-MHz mode; the purpose of using it was to test the boards above 7 MHz. This system also had 640KB of memory (256K- and 64K-bit chips, all rated at 150 ns), the identical model of Seagate hard disk (but with a Western Digital controller), one diskette drive, an ATI EGA card, and the same 2MB AST RAMpage! (but with no backfill of system board memory).

American Computer and Peripheral. The American Turbo is the smallest board in the group and the simplest in design. It comes with a replacement 8088 rated at 8 MHz, a switch box containing a speed switch and reset button, and a DIP (dual in-line package) socket intended to be soldered onto the motherboard in case the 8284 is not already socketed. This component turns out to be indispensible even if the 8284 is removable.

The board itself plugs into the socket vacated by the 8284 chip. Care must be taken to line up the pins on the underside of the board with the holes in the socket; even so, the pins are a tight fit. They would not enter the socket when pushed, even with an amount of force sufficient to put an alarming bend in the motherboard. Stressing a multilayer board in such a way can break a trace in one of the interior layers, which is enough to ruin the board. This is where the extra socket comes in handy. It is plugged onto the underside of the turbo board, and that assembly is plugged into the motherboard socket. Besides making insertion much easier, this yields the additional benefit of raising the Turbo board above the motherboard components adjacent to the 8284 socket, thus allowing unrestricted airflow for cooling. This use of the extra socket is not mentioned in the instructions.

Once the board is mounted, the rest of the installation goes smoothly. The reset and speed switches are of good quality and mounted in a heavy-gauge, black metal box that bolts to the outside of the back panel next to the power switch. The cable connecting the switches to the board is keyed to prevent plugging it in backwards.

A major disadvantage of the American Turbo is that it has only one clock speed, 7.37 MHz. This is too fast for most 200-ns memory chips; in fact, the board would not work in the IBM system. The documentation plainly states that memory chips must be rated at least at 150 ns, and that, if used, an 8087 numeric coprocessor must be rated at 8 MHz. But this information should be on the outside of the box. As it is, the only warning on the exterior is that installation requires the removal of

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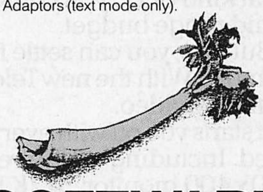

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the 8284 chip. True enough, but not a complete indication of the requirements for successful operation.

The results obtained with the American Turbo are consistent with its clock rate. The reset switch performed reliably, permitting the speed to be switched between high and normal at any time. The speed at boot-up can be set at either high or low using the turbo switch on the black box.

For the most part, the installation instructions are clear. The 20-page manual contains many diagrams and photographs, but its presentation is marred by numerous typographical errors that are present. Furthermore, the documentation is missing any mention of the company's address or telephone number (the simple fact that it should be there aside, American Computer and Peripheral offers a service to desolder the 8284 and install it in a socket).

The American Turbo leaves a mixed impression. In systems that can run at its one speed, it works fine. But with other boards offering multiple speeds at similar prices, little is left to recommend this one.

Maynard Electronics. The Surprise! board offers the easiest installation of the group. Following removal of the 8088, a special carrier is plugged into the microprocessor socket. This carrier is easier to install than a replacement chip because its pins are sturdier and already at the proper spacing. In addition, it is symmetrical, for installation in either direction. Once in, the carrier turns the processor socket into a short slot with 40 pins instead of 62. The Surprise! then plugs into this slot like an expansion card (but in one direction only). This ease of installation comes at a price, however; the Surprise! falls at the top end of the price scale and at the bottom end of the performance scale among these competitors.

The Surprise! board incorporates a V20 that, strangely, is soldered, not socketed. The processor runs at 9.54 MHz, or exactly twice the normal rate. This speed is obtained by a frequency-doubling circuit that takes its input from the original 4.77-MHz processor clock. However, only the supplied microprocessor can run at this speed. To synchronize it with the slower motherboard components, the Surprise! adds two or three wait states per bus cycle. The net effect is about the same as that of a simple clock accelerator running at 6 to 6.5 MHz—but the Surprise! costs twice as much as the others.

The speed at boot-up is controlled by a jumper on the board. Subsequently, speeds can be changed by running a transient program, or, if the supplied SURPRISE.SYS device driver has been installed through CONFIG.SYS, via a hot-key combination. On a keyboard reset, the system reboots at the speed last in effect, not at the speed indicated by the jumper. Surprise! provides no hardware reset capability.

SURPRISE.SYS can do more than simply switch speeds. It also improves the speed of several functions by replacing some DOS routines. Its effect is especially noticeable in writing to a CGA screen; and display-bound functions, such as the DOS DIR command, are remarkably faster. Its impact on compute-bound programs or programs that bypass DOS is barely discernable.

This driver effects these changes by repointing both the interrupt 20H (program terminate) and interrupt 21H (DOS function) vectors. Interrupt 20H normally points to IBMDOS.COM, and is interrogated by many programs to determine the segment location of DOS. With SURPRISE.SYS installed, these programs will cease to work.

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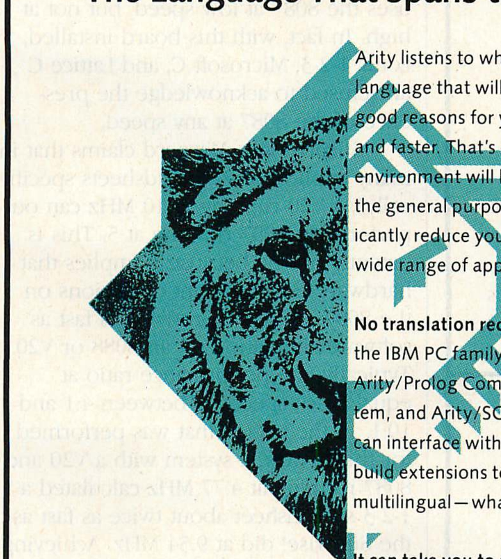

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One reason for knowing the DOS segment is to find the print echo switch, which is toggled by Ctrl-PrtSc and Ctrl-P. SURPRISE.SYS seems to lose track of this switch, causing print echo to behave erratically. Print echo can be turned on at either clock speed, but it can be turned off only at slow; once turned on (at either speed), it remains on at high speed at all times. (The Maynard technical support personnel acknowledged only that printing does not work properly at high speed because of "timing loops" within the print control routines. It was suggested that the user switch to low speed whenever print echo is desired. No problem occurred with printing itself at high speed, only with recognizing when the DOS print echo switch had been turned off.)

Another problem with the Surprise! is that it fails to recognize an 8087. The documentation states that the Surprise! uses the 8087 at low speed, but not at high. In fact, with this board installed, Lotus 1-2-3, Microsoft C, and Lattice C all refused to acknowledge the presence of the 8087 at any speed.

Surprisingly, Maynard claims that in many applications (spreadsheets specifically), a V20 running at 10 MHz can outperform an 8087 running at 5. This is patently untrue because it implies that hardware floating-point operations on the 8087 are less than twice as fast as software simulation on an 8088 or V20. Typically, the performance ratio at equal clock speeds is between 4:1 and 10:1. In the testing that was performed for this review, a system with a V20 and 8087 running at 4.77 MHz calculated a 1-2-3 spreadsheet about twice as fast as the Surprise! did at 9.54 MHz. Achieving half the execution time at half the clock rate equates to an actual fourfold improvement in the rate of computation with the use of an 8087.

The documentation is fairly complete, but it comes in too many pieces: the installation instructions are on one sheet, technical information is on another, and these pieces are in addition to an assistance booklet, another outlining Maynard's customer service plan, and several sheets with the software license agreement, registration cards, product comment forms, and so forth. One booklet is much preferable.

Ease of installation notwithstanding, the Surprise! cannot be recommended because of its interface problems with DOS and the 8087. Even putting this aside, the board is overpriced for the performance improvement it offers.

Megahertz Corporation. The TurboSwitch board provides not just two or three higher speeds, but ten, controlled by a rotary switch that mounts on the front panel of the system unit. This permits running the system very close to its maximum speed and changing the speed without reinstalling the TurboSwitch. As enticing as this may sound, the problems that arise in the installation and operation of this board may outweigh the advantages of not wasting some minor portion of speed capability.

This board's installation is far more complicated than any of the others. First, the 8088 is unplugged and replaced with a supplied 8-MHz 8088-2. Then, the 8284 chip is removed from the motherboard and plugged into a socket on the TurboSwitch board (each of the other accelerators has its own 8284). A ribbon cable connects the TurboSwitch and the 8284 socket. Only one end of the cable is marked to prevent its being plugged in backwards; the orientation of the other end is specified only in the instructions. (In this particular case, experience with connecting PCB components is not a help, because the cable is installed contrary to the standard conventions: the striped edge does not connect to pin 1.)

Apart from that quirk, the installation thus far is quite ordinary. At this point, however, one of the power connectors from the power supply must be removed from the motherboard and plugged into a receptacle on the TurboSwitch board; a short cable then connects from the TurboSwitch to the motherboard power connector. Next, the A: drive must be unmounted and slid forward to reveal the direct memory access (DMA) chip on the motherboard. A spring-loaded grabber clip (of the type used on the end of test instrument probes) is connected to one of the pins of the DMA chip; then the disk drive must be slid back into place without dislodging this connection. The TurboSwitch board is mounted by a clip to the back panel, hanging above the 8088 and 8087 sockets.

That is the easy version of the installation. For a system with a soldered 8284, five more clip-on connections must be made to various points on the motherboard. Worse, the documentation for this is literally sketchy, showing line drawings only of the chips, not their names. Also note that owners of compatibles with different component layouts are simply out of luck.

Hooking leads onto chip pins is certainly less expensive than paying a serviceman to mount a socket, but the added reliability of the latter approach could be worth the extra expense. In

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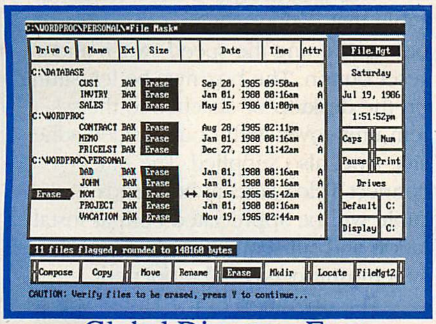

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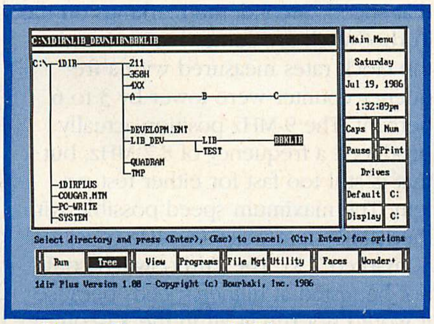

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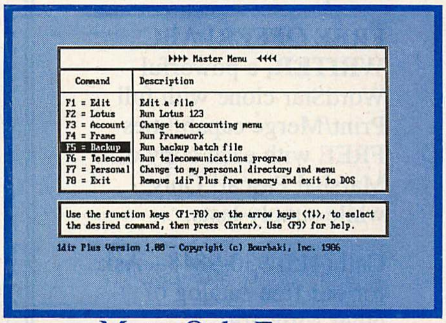

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the course of testing, the connections slipped off several times, crashing the system. Furthermore, one of the connecting wires eventually broke off from its soldered connection on the Turbo-Switch board. Perhaps the test process subjected the connections to more poking and prodding than would be done normally in a buttoned-up production system, but this scheme is definitely not recommended for a portable machine, or even for a desktop system that is moved from time to time.

Yet, installation of this board is still not complete. The box containing the speed control and reset switches must be mounted to the front panel of the system unit cover using bolts through the vent slots under the nameplate. Another ribbon cable, this one keyed at both ends, connects the switch and the board. With the switch on the cover, the board on the chassis, and the connecting cable on the inside, opening and closing the system unit can become somewhat complicated.

The switch box contains a ten-position rotary selector for clock speeds marked from 6.1 to 9.0 MHz, and a toggle switch that chooses either the normal speed of 4.77 MHz or whichever high speed is set on the selector. A third, spring-loaded position of the toggle switch provides a reset function. Boot-up may be accomplished at either normal or high speed.

Despite the switch markings, running a PC at 9 MHz is wishful thinking on two counts. First, no 8088-based IBM PC or compatible system is capable of that speed. Second, the markings on the TurboSwitch are somewhat optimistic; the clock rates measured with a frequency counter were lower by 3 to 6 percent. The 9-MHz position actually produced a frequency of 8.7 MHz, but that is still too fast for either test system. The maximum speed possible with the IBM system was 7.06 MHz (position 5, marked 7.5). The TurboSwitch could not be tested at higher speeds because it would not run at all in the XT-compatible system—there it simply refused to boot at any setting.

The TurboSwitch uses resistance capacitance (RC) circuits rather than quartz crystals to generate frequencies above 4.77 MHz. The reasoning behind this choice is obvious: ten crystals would be much more expensive. However, it delivers less precise control and is more subject to failure than a crystal-controlled oscillator circuit.

Using its connection to the DMA chip, the TurboSwitch board can detect disk I/O and reduce the system speed for the duration. Therefore, DOS FORMAT can be run without switching back to normal speed. Surprisingly, this board's performance in the disk-intensive tests was not significantly better than that of boards that do not decelerate during disk access.

The bottom line recommendation on the Megahertz TurboSwitch is not overwhelmingly positive. Although it has no fatal flaws, neither does it offer any operational advantages to compensate for the intricacies of installation or for the shortcuts in design.

Microspeed. To put it simply, the design, execution performance, and documentation of the Fast88 is the best in this field of simple accelerator boards. It contains three crystals to run at speeds of 6.14, 6.67, and 7.37 MHz. The manual says these are meant for systems with memory chips rated at 250, 200, and 150 ns, respectively. The choice is made at installation by means of a jumper. Another jumper enables or disables the reset button—this is the only board to carry such an option.

Installation involves replacing the microprocessor with a supplied 8-MHz 8088-2, removing the 8284, and connecting a ribbon cable between its socket and the Fast88. The connectors are not keyed, but the cable is plainly marked and the instructions are more than adequate to avoid confusion. The board itself attaches with screws to the inside of the back panel, over the round knockout of a PC or the DB-25 opening of an XT. The mounting bracket is cleverly designed so that a telephone-style modular jack on the board lines up with the opening.

This jack accepts a short length of cable that connects with a small plastic box containing the speed switch and a reset button. The box may be left sitting on the desktop or attached to the system unit cover with double-sided adhesive tape, also supplied. The quick-connect Telco jacks at both ends of the cable will be appreciated both at installation and subsequently whenever the system unit needs to be opened.

The operation of the Fast88 was as smooth as the installation. As stated in the manual, the board could run no faster than 6.67 MHz in the IBM system with 200-ns memory chips; it did run at 7.37 MHz in the XT compatible (with 150-ns chips). Speed switching and resetting worked flawlessly every time.

The Microspeed documentation also is first-rate material. An exhaustive, 64-page booklet covers not only installation, but also the design criteria and theory of operation. It even has an in-

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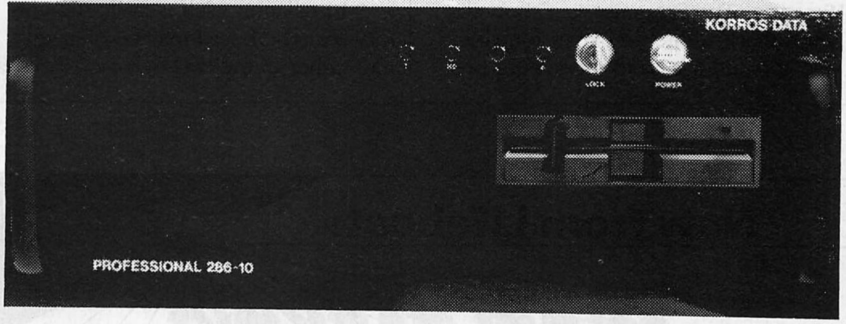

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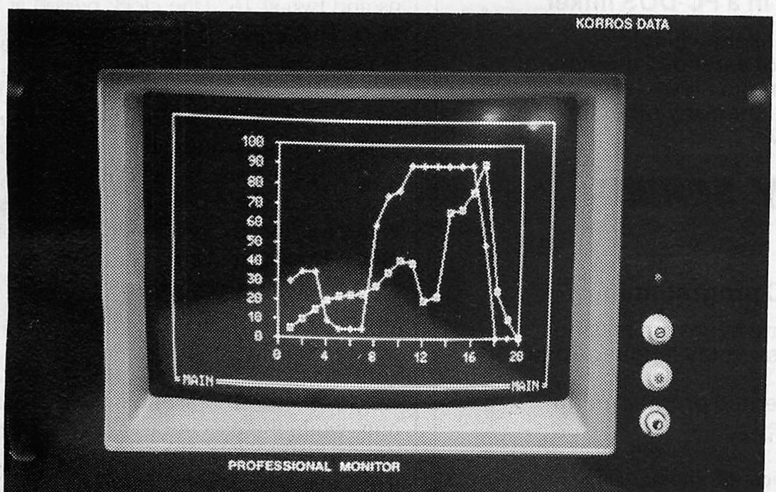

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dex—an unheard-of luxury in instruction manuals of this type.

The Fast88 is a superior product, the choice by far in this field. The only possible improvement would be to substitute a V20 processor for the 8088-2. But even as it was tested, the Fast88's cost/performance ratio is the best, especially if cost takes into account not only money, but also that other scarce resource, expansion slots.

Microsync. The Screamer is a short-slot board that fits into an expansion slot. With this full access to the system bus, it can adapt itself better to the capabilities of the system and exert some control over the system's timing. A battery-backed clock/calendar is included, but unlike most devices that are used only to set the system clock at boot-up, this one plays a significant role in the board's operation. Despite a complex and convoluted design, the Screamer turns in very ordinary results, and it has one very serious failing.

Installation itself is fairly straightforward. The board may be plugged into either of the two rightmost slots; a switch must be set if it is installed in slot 8 of an XT. The system's original microprocessor is unplugged and replaced with a V20. The 8284 is removed from its socket, then a special socket with some of the pins removed is plugged in its place, and the 8284 is plugged into that. The connection between the board and the 8284 is made by means of a single wire terminated with a clip that snaps over the clock chip. The final step is the running of an installation program and the setting of the Screamer's DIP switches according to an on-screen diagram. The switch settings can be changed while the system remains powered; the purpose of these switches becomes clear upon examination of the board's design.

The Screamer generates three clock frequencies: 4.77, 6.0, and 8.0 MHz. At any given instant, the clock rate will vary according to the capabilities of the components being accessed. For processor-only operations, the 8-MHz rate is used; for other activities, the rate is controlled on a cycle-by-cycle basis. This has the effect of "stretching" portions of a bus cycle without using wait states. During a bus cycle that reads or writes slow memory, only two of the four clock cycles are lengthened.

On the surface, this scheme seems preferable to inserting wait states. At a clock rate of 8 MHz, a bus cycle with a single wait state lasts 625 ns (five clock cycles of 125 ns each), while a four-clock cycle with two clock cycles at 125 ns and two at 167 (the clock period at 6 MHz) lasts only 584 ns. But in practice, lengthening cycles exacts more of a penalty than inserting wait states. This is so because the 8088 and V20 processors perform two activities at once: prefetching of instructions and execution.

Most of the time, while a bus cycle is in progress, the processor's execution unit is busy crunching an instruction fetched on a previous bus cycle. If the clock cycle is lengthened, fetching and execution are slowed down together. On the other hand, inserting a wait state slows down only the bus interface unit, while the execution unit continues to move along at full speed, provided that it has a prefetched instruction to work on. In fact, a single wait state in a bus cycle exacts no penalty whatsoever if the currently executing instruction takes five or more clock cycles; two wait states have no effect during execution of an instruction of six or more clock cycles, and so on.

The Screamer's installation program tests the DMA channels and each portion of memory and attempts to de-

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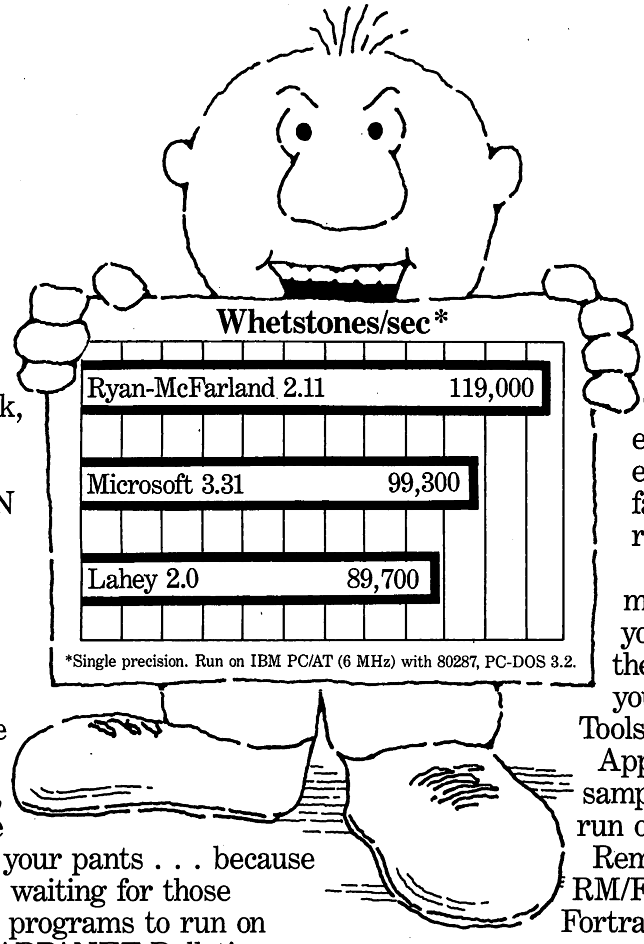

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termine the maximum speed at which each will operate. Because it sits in a slot, the Screamer has access to the address bus and can vary the clock rate depending upon the segment being addressed at each cycle. Memory is tested in 128KB increments all the way through the 1MB address space, including video memory, any expanded memory page frames, and ROM. At the completion of testing, the program graphically displays the switch settings.

Instructions for setting switches are also given in detail in the documentation. This is fortunate because the test program is not wholly reliable, and its recommendations do not always work. For example, on the PC test system with 200-ns RAM chips, the test procedure specified switch settings for a constant 8-MHz clock rate to all of memory. But with these settings, the system crashed whenever it was switched into high speed. The board ran well when set for a 6-MHz rate of memory access.

Another switch controls the bootup speed of the Screamer. Thereafter, the speed is switched via a supplied program that can be either resident or transient. Once the proper switch settings were determined, no problems were encountered with switching among the three speeds.

At high speed, the Screamer's average clock rate, as measured with a frequency counter, varied between 6.5 and 6.8 MHz, depending upon the activity. Most of the time, the counter would stabilize at 6.67 MHz, which is the result of 60 percent of the clock cycles at 6 MHz and 40 percent at 8 MHz. (The average frequency is obtained by averaging not the 6 and 8, but the periods of 167 and 125 ns.) The benchmark results are almost identical to those obtained with boards that were running at a constant 6.7 MHz without any of this complexity with the clock.

However, the most serious flaw in the Screamer's design is the fact that it does not provide the standard timer input frequency of 1.1932 MHz. Because only one original 8284 is present, the processor clock and timer signals cannot be separated, and the 8253 timer chip receives one-quarter of whatever frequency is being fed to the microprocessor. In the Screamer, this can vary from cycle to cycle, thus the timer does not have a constant time base. The video synchronization, however, is unaffected, because the 14.3-MHz oscillator from the original crystal continues to be fed to the expansion slots.

To salvage the time-of-day capability, an installable device driver replaces the DOS clock device and maintains the correct time despite the variations in the timer frequency. However, this does not fully duplicate the standard clock facilities because the correct time is maintained only by the Screamer's onboard clock/calendar and is available only through DOS. The timer words in the BIOS data area do not reflect the true time of day, nor are they updated at the actual time rate. Thus, processes that measure elapsed time by reading the timer words (or, for more resolution, the timer registers) directly will not obtain the correct values. Further, the frequencies of sounds produced by the speaker are very different.

IBM has made a commitment to maintain a fixed timer input frequency in all members of the PC family. Microsync's disregard of this standard is unwarranted. Providing a substitute date and time driver is not sufficient, because the timer frequency has other uses. For compatibility across the PC line, programs should take time-critical information from the timer, and the most efficient way of doing that is not

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through DOS, but directly from the BIOS or timer words, or from the timer's registers. With the Screamer installed, the timer becomes useless. It is primarily for this reason that the Screamer is not a recommended product. Even so, the cost and complexity of this accelerator are not justified by the performance it delivers.

MicroWay. Although the 87/88 Turbo is a short-slot board that plugs into an expansion slot, it is basically the same type of clock accelerator as the other no-slot boards. It runs an 8088 or V20 in the original motherboard socket and feeds its higher-speed clock signals through the original 8284 socket on the motherboard. However, with full access to the bus, this board can do some tasks the others cannot, such as switching speeds with software and automatically slowing down for disk access. In addition, it includes a battery-powered clock/calendar for setting the system clock on power-up.

The 87/88 Turbo comes with an 8-MHz V20 and three crystals that generate frequencies of 6.67, 7.37, and 8.0 MHz. The crystal for the slowest of these is soldered to the board; one of the other two is to be plugged into a socket. Then, a jumper is set to choose one of the two remaining frequencies as the turbo speed. The choice of 6.67, 7.37, or 8 MHz can be made only at installation, not during operation. It would have been much clearer, therefore, to provide only one method of choosing—either by a jumper that selects one of three premounted crystals, or by plugging one of three into the board. The purpose of providing three clock speeds is, of course, to allow tailoring the speed to the capabilities of a particular machine, but there seems to be no overwhelming reason to have two crystals, rather than one or three, mounted on the board.

The socketed crystal does offer one option not available with the other boards. For a system that can run faster than 6.67 MHz but cannot manage 7.37, the user can purchase and plug in a crystal for some intermediate speed. The crystal frequency needs to be three times the desired clock rate; for example, a 21-MHz crystal is needed for a clock rate of 7 MHz.

The documentation for this board, consisting of five 8½-by-11-inch sheets of paper, contains installation instructions that are a model of conciseness and clarity. MicroWay has always targeted its products to the more experienced PC user, for whom it is a pleasure to be spared the tedium of yet another explanation of how to take off the system unit cover or what exactly an AUTOEXEC file is and how to add lines to it. But the user who needs this kind of instruction will find the lack of technical information frustrating. The pages provide absolutely no detail regarding the board's theory of operation, the I/O port addresses used by the clock and the speed switching hardware, nor any explanation about the operation of any of the supplied resident programs. The port addresses given here were discovered by disassembling the programs.

The process of installation involves replacing the 8088 with the V20, inserting the 87/88 Turbo into a slot, removing the 8284, and connecting a ribbon cable between the board and the vacated socket. The cable is keyed at one end, and pin 1 is plainly marked on the other. A push-button reset switch mounts in the round knockout in the rear panel; its cable is too short, however, to permit mounting in a more accessible location for the user.

The system always boots up at 4.77 MHz. Thereafter the speed can be changed in one of three ways: first, by means of a spring-loaded switch that protrudes through the mounting bracket —pressing it *down* causes the system to speed *up* into turbo mode, and vice-versa (although a minor point, the reverse would have seemed more logical); second, by running one of two programs, LARGO and PRESTO, either from the DOS prompt or from a batch file; third, by installing a supplied resident utility that performs speed-switching via hot keys. However, the key combinations of this last choice seem rather arbitrary and not mnemonic: Ctrl-Alt-P for fast speed, Ctrl-Alt-L for slow.

The MicroWay instructions suggest starting out at the highest speed (8 MHz) and stepping down until the system does not crash upon shifting into high speed. As stated, the test PC system would not run faster than 6.67 MHz. Strangely, the board would not run at 8 MHz in the XT compatible, even though that machine has built-in capabilities to operate at that speed.

This suggests that the 87/88 Turbo makes no concessions to slow system components, and indeed, it used zero wait states. But this board gives the user one element of control not provided by any of the others: the choice of automatically switching into slow speed for all disk accesses. If a resident utility is installed, slow speed is entered at each disk I/O interrupt, and the former speed is reenabled afterwards. Without this utility, disk I/O proceeds at what-

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ever clock speed is in effect. The other boards that have the capability of slowing down for disk I/O do not offer the option of disabling it.

The MicroWay 87/88 Turbo operation was flawless. As its name indicates, it also works well with an 8-MHz 8087. The installation instructions are first-rate, but it has no technical documentation. Although it has some minor, but irritating, design flaws, the product works as promised, and the price is reasonable. For systems with no shortage of slots, and especially for those in need of a clock, MicroWay's 87/88 Turbo merits consideration.

GOING FAST ENOUGH

The accelerator boards were examined with measuring equipment and benchmark programs. Clock frequencies were measured using a frequency counter. For the boards with crystal-controlled oscillators, and for those that doubled the 4.77 Mhz from the motherboard, the frequencies were found to agree with the nominal indicated to better than 0.1 percent (the output of a crystal oscillator may be varied over a narrow range with a trimming capacitor). Only one board, the Megahertz TurboSwitch, generates frequencies with less stable RC circuits. Its output is below the nominal by as much as 5 percent, and varies generally by about 1 percent. The Microsync Screamer also varies, but that is by design; its two individual frequencies are derived from a crystal oscillator and both are steady.

A logic analyzer was used to determine the insertion of wait states into bus cycles. This instrument samples a number of signals from a system under test, recording the logic state (zero or one) of each signal at each clock pulse. The capacity of the unit used was 4,000 bytes, meaning that 4,000 clock cycles could be stored with an 8-channel probe, or 2,000 with a 16-channel probe. The start of sampling can be triggered manually or by the occurrence of a particular bit pattern on the sample lines. At the end of the sampling interval, the stored data can be displayed on the unit's screen in binary, octal, or hexadecimal numbers, or graphically as timing diagrams similar to the one shown in figure 3.

Because it ran at a faster clock speed (9.55 MHz) than the other five products, the Maynard Surprise! was the only board found to insert wait states into the bus cycle. The number of wait states is at least two, and occasionally three, for memory cycles, and four to six when accessing I/O ports.

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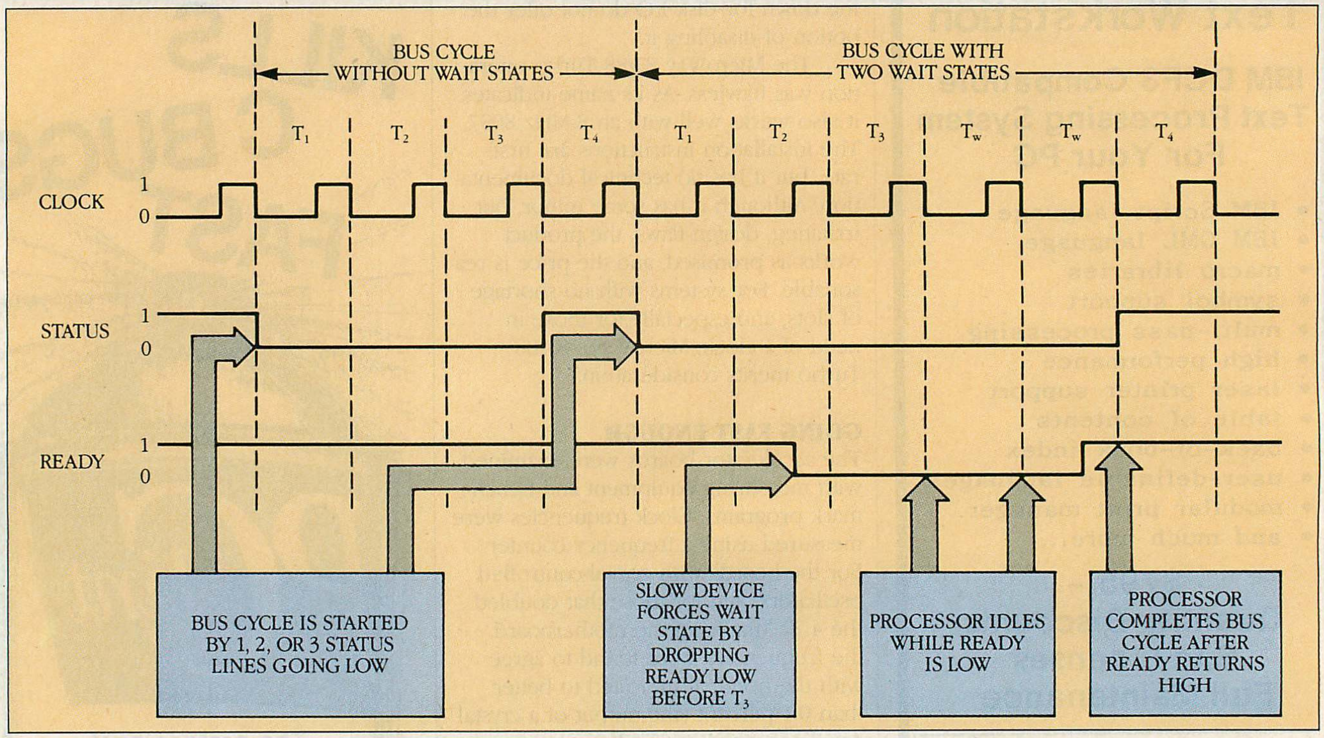
FIGURE 3: *PC/XT Bus Cycle Timing*



The asynchronous changes in the state of READY are brought into synchronization with the system clock by logic within the 8284 clock generator chip. (See figure 1.) Note that the READY line has no effect on the T3 clock cycle.

In designing benchmark programs to test these accelerators and the more complex models in future installments, one factor became immediately obvious: it is not possible to devise a single numeric measure that rates the relative speed of processing under all conditions. A microprocessor performs many different functions, and its throughput can be increased by improving the speed or efficiency of several of these functions in varying degrees. The effective improvement seen by the user depends upon the particular mix of these functions performed by a given application. The apparent gain in performance will vary depending upon the task used to measure that performance.

Therefore, several different benchmarks were devised to test performance under a variety of conditions. With one exception, these tests are practical applications, not artificial sequences of instructions contrived to exercise some limited aspect of the microprocessor's capabilities. The benchmark results are shown in table 2. Where two speeds are listed for a board, the lower of the two was achieved in the PC system described, the higher in the XT compatible. Note that the American Turbo was tested only in the compatible because its one speed was too fast for the PC; the Megahertz TurboSwitch would not run in the compatible; and the Maynard Surprise! ran at the same speed in both.

BUSPERF (written in Lattice C and assembly language) was the one benchmark designed specifically to determine low-level timing characteristics (see listings 1 and 2). It tests the speed with which systems fetch instructions from memory and calculates a speed index relative to a standard PC running at 4.77 MHz. Measuring bus access timing requires a sequence of instructions for which the execution time is limited by the bus; that is, each instruction must execute in less time than it takes the bus unit to fetch it. The 8088 requires at least eight clock cycles to fetch a two-byte instruction; therefore, any instruction that executes in fewer than eight clock cycles satisfies the requirement for this test. Ideally, the same test should be applicable to 80286 machines, and the processor should fetch word-long instructions in a minimum of two clock cycles. Some two-byte instructions do execute in two clock cycles, namely register-to-register moves.

The high-resolution (better than 1 μs) timing method required for this test was developed by Bob Smith and Tom Puckett (see "Life in the Fast Lane," April 1984, p. 62). Basically, the timing routine counts the pulses on the 1.1932-MHz timer line (refer to figure 1).

The timing sequence is coded in straight-line fashion, rather than as a loop, to prevent the LOOP instruction from upsetting the balance between execution and fetch times. One other precaution must be taken: the timed sequence cannot be interrupted by a hardware interrupt. The obvious way to avert this is to disable interrupts, but that still leaves one problem. If the timer count reaches zero during the test, the time at the end of the test may be less than the time at the start. Instead, the test is made to fit between timer ticks by delaying the start of the test until a tick occurs and limiting the instructions in the sequence so that they can be executed in less than the 55 ms before the next timer tick.

The primary purpose of BUSPERF is to complement the logic analyzer in finding wait states. The analyzer can determine precisely the number of wait states and the circumstances when each occurs, but only in a relatively short time span of 4,000 clock cycles. If an event that affects the system's timing occurs outside of this interval, it is not reflected in the data stored in the analyzer. On the other hand, BUSPERF can determine average bus access time over a time period two orders of magnitude (100 times) longer. In more colloquial terms, the analyzer might miss the for-

TABLE 2: *Benchmark Results*

	IBM CORPORATION		AMERICAN COMPUTER	MAYNARD ELECTRONICS	MEGAHERTZ CORPORATION	MICROSPEED		MICROSYNC	MICROWAY	
MODEL	PC	PC	American Turbo	Surprise!	TurboSwitch	Fast88		Screamer	87/88 Turbo	
MICROPROCESSOR	8088	V20	8088-2	V20	8088-2	8088-2		V20	V20	
CLOCK SPEED (MHz)	4.77	4.77	7.37[a]	9.55	7.06	6.67	7.37[a]	8.00	6.67	7.37[a]
CLOCK SPEED RATIO	100	100	155	200	148	140	155	168	140	155
BUSPERF	0.045[b]	100	159	132	150	142	159	—[c]	143	159
ATFLOAT										
No 8087	106	124	158	166	151	142	158	174	160	196
With 8087	22	116	158	—[d]	151	142	157	159	157	175
ASSEMBLY OF VDISK	34	110	158	148	148	142	156	154	154	172
LOTUS 1-2-3										
No 8087	122	103	157	152	147	141	155	161	159	187
With 8087	41	106	153	—[d]	149	142	157	157	156	179
dBASE SORT	119	106	146	115	118	115	147	118	119	145
WORD REPAGINATE	50	111	152	156	156	148	170	156	161	192
DOS FORMAT	●	●	○	●	●	○	○	○	○	○

● = *Yes* ○ = *No*

[a] *These results were obtained with the board in a PC/XT-compatible machine (with 8.0-MHz capacity), in order to accommodate the higher clock speed.*
[b] *The figures in the first column (from this test down) are times in seconds for the base machine—an IBM PC with a 4.77-MHz 8088. The remainder of the figures for the tests (including the second column, which is the base PC with the 8088 replaced by an NEC V20) are percentages relative to the first-column unit figures (base 100), and represent the increase in PC performance yielded by the accelerator boards.*
[c] *BUSPERF relies on the IBM standard timer frequency, which is altered by Screamer.*
[d] *Surprise! does not allow the use of the 8087 numeric coprocessor.*

The impressive clock rate of the Surprise! does not give a proportional performance improvement. The use of wait states by the Surprise! brings its performance down to a level comparable to the other products. None of these products provides even twice the performance of a stock PC, a level considered by many to be the minimum significant performance enhancement.

est for the trees, while the program alone could be the statistician who drowned in a lake with an average depth of two feet.

For an example of how the analyzer and the program complement each other, consider the results obtained for the Maynard Surprise! The analyzer indicated that, most of the time, two wait states were inserted into memory accesses, with an occasional bus cycle having three wait states. How can it be determined if this is the normal state of affairs and not an artifact of the narrow sampling window? Perhaps in a wider time frame, the cycles with three wait states are more prevalent, and those with two are an exception.

Some simple calculations, and the results of BUSPERF, provide the answer. At the normal speed of 4.77 MHz and with zero wait states, a bus cycle takes four clock cycles of 210 ns, for a total of 840 ns. At 9.55 MHz, the clock period is 105 ns, and a bus cycle with two wait states (six clock cycles total) takes 630 ns. The ratio of the bus cycle times, 840/630, is 1.33, almost exactly the result produced by BUSPERF. Therefore, it follows that the Surprise! inserts two wait states into most bus cycles.

However, because of the occurrence of cycles with three wait states, the average calculated by BUSPERF should be somewhat higher than the ratio obtained by the above calculation; instead it is slightly lower. This difference can be explained by the saving in overhead for DMA refresh cycles.

Under normal circumstances, every 72 clock cycles (15 μs at 4.77 MHz), one of the DMA channels performs a dynamic memory refresh to prevent the contents of RAM chips from fading away. The refresh cycle takes five clock cycles, representing an overhead of 5/72 or 7 percent. The refresh cycles are triggered by the timer chip (the input for which is the 1.1932-MHz timer clock), and a correctly designed accelerator board does not change this frequency, so that the refresh interval remains 15 μs. But if the processor clock runs at twice the speed, 144 clock cycles occur between refresh cycles. With, for example, three wait states per refresh cycle, the refresh overhead would be (5 + 3)/144 or 5.5 percent. In the case of the Maynard Surprise! board, this reduction in refresh overhead approximately offsets the occasional insertion of a third wait state.

Because the results reported by BUSPERF depend on a constant timer frequency, this test could not be run on the Screamer. With that board, the timer frequency changed along with the processor clock, so the relative speeds of the timer and processor were the same (at 4.77 MHz). As a result, BUSPERF gave a bus speed index of 1.0.

The other benchmarks are more straightforward. ATFLOAT is a floating-point benchmark written in Microsoft C by Steven Armbrust, Ted Forgeron, and Paul Pierce for testing AT compatibles. (See "Out from the Shadow of IBM...," August 1986, p. 53.) It has no processor-specific code and runs on 8088 and 8086 processors, with or without an 8087 (and the test was performed both with and without). Note that at clock speeds above 5 MHz, the 8-MHz 8087-2 model must be used. Five of the six accelerators ran fine at both high and normal speeds with the 8087. As has been noted previously, the exception was the Maynard Surprise!

The assembly test used Microsoft's MASM 4.0 to assemble the DOS 3.2 version of VDISK.SYS. The source code was obtained by processing the listing file VDISK.LST (on the DOS Supplemental Programs disk) with the BASIC program LST2ASM (previously published with "Same Language, New Architecture," Ted Mirecki, October 1985, p. 48.) To minimize timing differences caused by disk I/O, the assembler,

source file, and object file all resided on a RAM disk in expanded memory. To avoid taking timings manually, the following batch file was used:

```
TIME 0
MASM VDISK;
TIME
REM Reset your clock or run boot-up
    clock program.
```

Typical end-user applications are represented by Lotus 1-2-3, Ashton-Tate's dBASE III, and Microsoft Word. The 1-2-3 spreadsheet calculates a monthly mortgage payment table using the Data Table 2 feature. The rows of the table are the life of the loan in years, with values varying 1 to 30 by 1. The columns hold the interest rates from 1 to 20 percent by .25. This is a more realistic business calculation than the more compute-intensive log, square root, or logarithmic functions. A file containing this spreadsheet, SSPERF.WK1 (for 1-2-3 release 2.0 or 2.01) is available for downloading on PCTECHline. For this test, the expanded memory was disabled to avoid timing effects of accessing paged memory. Despite the nonprocedural nature of spreadsheets, their recalculation timing may be automated by the following 1-2-3 macro:

```
{LET A1,@NOW}
    :
steps to be timed
    :
{LET A2,(@NOW-A1)*24*3600}
{GOTO} A2 ~
```

When complete, cell A1 contains the start time and cell A2 the elapsed time in seconds. The @NOW function returns a value for which the fractional part represents time of day (.0 is midnight, .5 is noon, .75 is 6 PM, etc.). The fraction representing elapsed time is converted to seconds by multiplying by the number of seconds per day. Of course, cells A1 and A2 can be in any convenient place in the spreadsheet, or, more effectively, they can be range names. The {GOTO} command at the end was put in as a work-around for what appears to be a minor bug in 1-2-3: the effect of a LET, which assigns a value to a cell, is not displayed until the next time the cell pointer is moved.

The dBASE III test consisted of sorting the author file from *PC Tech Journal*'s standard application for testing database managers (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46). The file contains 900 records of 353 bytes; the sort was done on three fields (ZIP, LAST_NAME, FIRST_NAME) totaling 35 bytes. The input and output files were on hard disk, so the results here are dependent upon the speed of the disk as well as the processor. Although the absolute time of this test may vary from system to system, the relative times on one system should be close to those in table 2. As expected, the improvement provided by an accelerator is less on a disk-intensive task than it is on more compute-bound activities.

The word processor test timed Microsoft Word repaginating a 57KB document occupying 19 pages. This was the only test timed using a stopwatch; the reported results are the average of five runs. The document resided on a hard disk, so this elapsed time also depends upon the disk speed, but to a lesser extent than the dBASE III sort because the disk access is less frequent.

The final test was the formatting of a diskette. Three of the six accelerators failed this, but three of them clearly documented the fact that formatting requires switching to normal speed. The boards that accomplish the task without manually switching out of high speed

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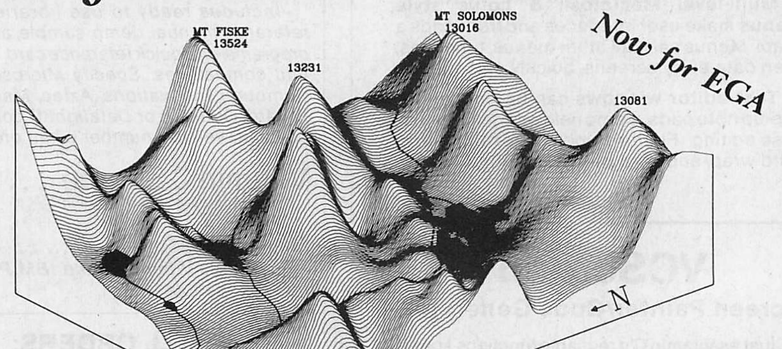

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are the Surprise!, the TurboSwitch, and the 87/88 Turbo, the last only after installation of a resident program that automatically switches to slow speed for the duration of disk access.

Several other tests were run as well, but all of the boards passed them uneventfully. These included the starting of software protected with Vault's SuperLok, and the booting of several games, including Microsoft Flight Simulator. All in all, no incompatibilities were found; but every board permitted switching to normal speed in the event problems did arise. This also points out one of the advantages of this type of accelerator: at slow speed, they are totally transparent and indistinguishable from the system's native hardware.

CHOOSING RELIABILITY

As the tests shows, none of these boards turns the PC into a blazing performer. This is simply a limitation of the basic design of this type of accelerator. In most cases, the improvement in performance, about 20 to 40 percent overall, is directly proportional to the increase in clock speed, and the clock speed itself is limited by the existing components in the PC.

Despite similarities among many of these products, certain differences stand out, and some recommendations can be made. First, the one board to avoid is the Microsync Screamer, because of its tampering with one of the declared constants of the PC standard, the timer frequency. As evidenced by the five other products, providing a faster processor clock without disturbing the timer input is not difficult to do, nor does it add significantly to the cost.

A negative vote must be registered against the Maynard Surprise! for not recognizing an 8087 at any speed. Users who want the speed advantage of an accelerator will no doubt find it hard to live without the advantages of a numeric processor. The Surprise! also has a problem with the DOS print echo switch. Finally, whatever performance gain is achieved when this board does work is simply not commensurate with its high price tag.

The American Turbo is very capable, and its installation is straightforward. But it has only one clock speed, 7.37 MHz. Buy it only for a system that has been tested at that speed.

At the top end of the spectrum, two products can be recommended in an otherwise unexceptional field. The first is the MicroWay 87/88 Turbo. It provides the most flexibility in methods of switching speeds, and it performs

very reliably. Its two minor drawbacks are that it takes up an expansion slot and that the documentation is somewhat lacking. But for a system that can spare a slot, and especially one that needs a battery-backed clock/calendar, it deserves consideration.

The standout is the Microspeed Fast88. Its high-quality construction, complete and comprehensive documentation, facile installation, and reliability in operation recommend it highly. Little else needs to be said, and that is meant as praise—a product of this type can be installed and forgotten.

The performance of a PC with a clock accelerator comes nowhere near that of an AT, period. But for a modest improvement at a modest cost, and at a level of compatibility that is higher than with more complex enhancements, this method of speed improvement is a worthwhile consideration.

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Ted Mirecki is a contributing editor to this magazine. He is a corporate planner responsible for developing decision support systems on a variety of hardware.

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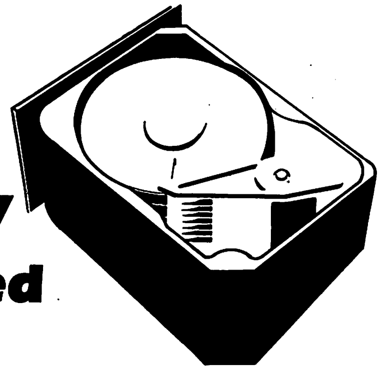

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LISTING 1: BUSPERF.C

```
/* Program for timing bus performance of IBM compatibles.

        By:  Ted Mirecki, October 1986.

        For LATTICE C compiler versions 2.x and higher;
        may require modifications for other compilers.
*/

long            basetime = 54001.0;    /* Timer count on base PC */
double  period     = 1/1.19318;    /* Microseconds per timer count */

int     timerset();       /* ASM functions in BUSPERFX.ASM         */
long    bustest();

main()
{
        long count;
        double msecs, index;
        static char dispform[] = "%-8s    %8ld           %7.3f\n";

        printf("\n\nBUSPERF -- PC Bus Performance Analyser\n");
        printf("         (C) Copyright PC TECH Journal 1986\n\n\n");

        timerset();                     /* initialize timer mode       */
        count = bustest();              /* perform the test            */

                                        /* calc & display results      */

        printf("                Timer Count   MilliSeconds\n");
        msecs = period * basetime / 1000.0;
        printf(dispform, "Base PC", basetime, msecs);
        msecs = period * count / 1000.0;
        printf(dispform, "This Run", count, msecs);
        index = (double) basetime / (double) count;
        printf("\nBus Performance index: %5.2f\n", index);
}
```

LISTING 2: BUSPERFX.ASM

```
TITLE   BUSPERFX - TIMER ROUTINES FOR PC PERFORMANCE TESTS

COMMENT "       Routines to time execution of various operations.
        Copyright (c) PC Tech Journal 1986
        Written by Ted Mirecki, Oct. 1986.

        Linkage conventions per Lattice C.
        Limitation:  test must not span midnight.
"
        INCLUDE DOS.MAC ;LATTICE INTERFACE DEFININTIONS
;*****************************************************************
;    DATA SEGMENTS
;*****************************************************************

BIOSDATA        SEGMENT AT 40H
        ORG     6CH     ;DEFINE TIMER WORDS AT 40:6C
TIMERLO DW      ?
TIMERHI DW      ?
BIOSDATA        ENDS

        DSEG                    ;MACRO TO OPEN DATA SEG (DOS.MAC)
T1LO    DW      ?               ;TIMER COUNT BEFORE CALIB
T1MID   DW      ?
T1HI    DW      ?
T2LO    DW      ?               ;TIMER COUNT AFTER CALIB
T2MID   DW      ?
T2HI    DW      ?
NEWSEG  DW      ?               ;SAVE ALLOCATED WORKSPACE
WORKDATA        DB      10 DUP (0)      ;SCRATCH AREA
        ENDDS                   ;MACRO TO END DATA SEG (DOS.MAC)
;*****************************************************************
;    MACROS USED IN CODE SEGMENT
;*****************************************************************

MARK    MACRO   TX
        CALL    TIMERGET        ;;GET CURRENT TIMER VALUES
        MOV     TX&HI,AX        ;;SAVE 3 WORDS OF TIMER
        MOV     TX&MID,BX
        MOV     TX&LO,CX
```

```
        ENDM
        PSEG            ;MACRO TO START PROG SEG (IN DOS.MAC)

;*******************************************************************
; TIMERSET:  INITIALIZE TIMER FOR INTERVAL TIMING.
;
;   Sets Timer 0 (the time-of-day counter) to mode 2, with a period
;       of 0 (equivalent to 65536).  This makes it a low-order
;       extension of the BIOS timer words.
;*******************************************************************
        BEGIN   TIMERSET

TIMER0  EQU     40H     ;I/O PORT FOR TIMER 0
TIMERCTL        EQU     43H     ;I/O PORT FOR TIMER CONTROL
SETMODE2        EQU     00110100B ;VALUE FOR MODE 2, 2 BYTES, BINARY

        MOV     AL,SETMODE2     ;SEND CONTROL BYTE TO TIMER
        OUT     TIMERCTL,AL
        XOR     AL,AL   ;SEND ZERO COUNTER VALUE (=65536)
        NOP             ;DELAY FOR PORT RECOVERY
        OUT     TIMER0,AL       ;SET LO BYTE OF COUNT
        NOP             ;DELAY FOR RECOVERY
        NOP
        OUT     TIMER0,AL       ;SET HI BYTE OF COUNT
        RET
TIMERSET        ENDP
;*******************************************************************
; TIMERGET: READ 3 TIMER WORDS INTO AX, BX, CX
;*******************************************************************

TIMERGET        PROC    NEAR
        ASSUME  DS:BIOSDATA

LATCH   EQU     0       ;COMMAND TO SAVE TIMER 0 COUNT

        PUSH    DS
        MOV     AX,BIOSDATA     ;POINT TO TIMER WORDS IN BIOS
        MOV     DS,AX
        MOV     AL,LATCH        ;PREPARE TO CAPTURE TIMER COUNT

        CLI             ;NO INTERRUPTS WHILE READING TIMER
        OUT     TIMERCTL,AL     ;LATCH THE TIMER COUNT
        MOV     BX,TIMERLO      ;GET TIMER VALUES FROM BIOS DATA
        MOV     CX,TIMERHI      ;HI TIMER TEMPORARILY IN CX
        IN      AL,TIMER0       ;READ LOW ORDER BYTE OF TIMER COUNT
        MOV     AH,AL   ;SAVE IT
        NOP             ;DELAY FOR RECOVERY
        IN      AL,TIMER0       ;GET HI ORDER BYTE OF COUNT
        STI             ;ALLOW INTERRUPTS AGAIN

        XCHG    AH,AL   ;RESTORE CORRECT ORDER OF BYTES
        NEG     AX      ;CONVERT TO UP-COUNT
        XCHG    AX,CX   ;GET 3 WORDS IN PROPER ORDER
        POP     DS
        RET
TIMERGET        ENDP
;*******************************************************************
; ELAPSED:  CALCULATE ELAPSED TIME INTERVAL
;
;  Input:  T3 timer values in AX, BX, CX;
;          previous values in T1 and T2 locations.
;  Output: Elapsed time value, (T3-T2)-(T2-T1), as
;          long int in AX:BX.
;*******************************************************************

        ASSUME  DS:DGROUP
ELAPSED PROC    NEAR
        SUB     CX,T2LO ;CALC (T3-T2)-(T2-T1)
        SBB     BX,T2MID
        SBB     AX,T2HI
        SUB     CX,T2LO
        SBB     BX,T2MID
        SBB     AX,T2HI
        ADD     CX,T1LO
        ADC     BX,T1MID
        ADC     AX,T1HI ;DIFFERENCE IN AX, BX, CX
        MOV     AX,BX   ;RETURN LONG INT IN AX,BX
        MOV     BX,CX
        RET
ELAPSED ENDP
```


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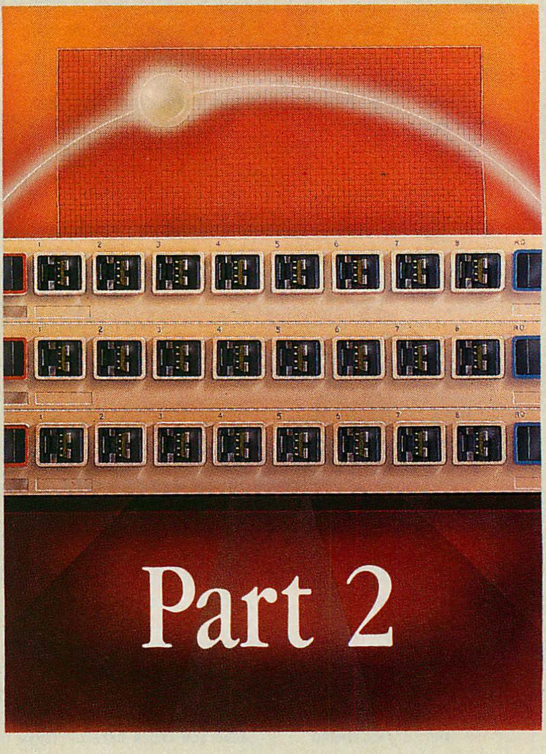
```
;*******************************************************************
;   BUSTEST:  TIME MEMORY ACCESS FOR INSTRUCTION FETCH
;*******************************************************************
        BEGIN   BUSTEST ;MACRO TO BEGIN PROC (IN DOS.MAC)
        PUSH    BP
        MOV     BP,SP   ;STANDARD C ENTRY SEQUENCE

        PUSH    DS
        MOV     AX,BIOSDATA
        MOV     DS,AX   ;POINT TO BIOSDATA SEGMENT
        ASSUME  DS:BIOSDATA
        MOV     AX,TIMERLO
STAY:   CMP     AX,TIMERLO      ;DID TIMER TICK OCCUR?
        JE      STAY    ;IF NOT, WAIT UNTIL IT DOES
        POP     DS
        ASSUME  DS:DGROUP       ;LATTICE DATA GROUP

        MARK    T1      ;GET INITIAL TIMER VALUES
                        ;SET-UP CODE, IF ANY, GOES HERE
        MARK    T2      ;END CALIBRATION, START TEST

;----------------- CODE TO BE TIMED BEGINS HERE.

        MOV     AX,BX   ;TWO-CYCLE, 2 BYTE INSTRUCTION
        DB      24999 DUP (89H, 0D8H)   ;PERFORM IT 25,000 TIMES

;----------------- END OF TIMED CODE

        CALL    TIMERGET        ;GET ENDING TIME (T3) INTO REGS
        CALL    ELAPSED ;CALC ELAPSED TIME IN AX:BX
        POP     BP
        RET
BUSTEST ENDP
;*******************************************************************
; END OF TESTS
;*******************************************************************
        ENDPS           ;MACRO TO CLOSE PROGRAM SEG (IN DOS.MAC)
        END
```

The Token-Ring Solution



Until standards are developed, users have to rely on individual assessments of LAN capabilities. Here are a few guidelines for choosing a system.

J. SCOTT HAUGDAHL

Many variables come into play in analyzing the performance of PC local area networks (LANs). With the introduction of the IBM Token-Ring Network comes yet another system structure that demands attention (see the "The Token-Ring Solution," J. Scott Haugdahl, January 1987, p. 50). Furthermore, developing benchmarks for LANs is difficult because no "typical" usage pattern has been established for an installed network. This article offers points for consideration, including a few caveats, and gives examples of limited LAN benchmarks, in this case conducted by IBM and Novell.

Because standards are as yet unestablished, planners must be careful in weighing vendor claims against the probable realities of implementing a system. For example, a vendor that publishes a benchmark for a specific task (such as a file transfer) may be simply highlighting a particular area in which its LAN outperforms the competition. In other cases, LAN vendors may make assertions that simply do not bear out.

A typical claim may be that the network uses "low-cost" twisted-pair cable (which is in more frequent use since IBM introduced its cabling system—see "Underlying Connections," J. Scott Haugdahl, December 1986, p. 126). Although this cable may be considered low-cost, installation is far more expensive than the wire itself. Vendors sometimes claim that they employ a nondedicated server, so that it can be used for more than one purpose (that is, as a file server/workstation, file/print server, and so on). This may be so, but the long-term costs in terms of performance, reliability, security, and integrity (not to mention employee down time on particularly slow networks) may nullify the savings realized initially in the hardware/software investment.

A vendor may claim that its LAN can host thousands of PCs. The number actually accommodated will typically be a limitation of the logical address space, not simply the comfortable number of PCs that can exist on a LAN without severe degradation in performance. (As a rule of thumb, the I/O response time on a LAN should be no worse than that of a stand-alone, diskette-based PC.) Related to this, a vendor may claim that a LAN can operate with an unrestricted number of simultaneous users, but again, a limit must be imposed somewhere to maintain performance standards. Software vendors that make this claim generally are using the extended file-locking (byte-range) and open modes provided by DOS 3.x. They are

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leaving determination of the actual limit up to the table capability of a file server and the realistic capability up to the user. In some cases, this type of multiuser software will not work at all with a disk server (such as a Nestar or an older Corvus LAN system).

Although some vendors claim that LANs are transparent to the user (that the user will notice no difference between using a LAN or a PC in a standalone environment), this is not entirely true. Users in a LAN must know how to handle delays, errors, concurrent access, and possibly having to assign virtual disk volumes. Neither is the system transparent to programmers: time-outs, semaphores, and record-locking procedures must be managed.

Finally, the multiuser databases used with LANs also offer varying capabilities. Users will need to know, for example, about the maintenance of the system's index structure, and if the locking techniques are hidden from the application. Even though a LAN may be distributed totally, meaning that any PC may share any resource with any other PC, it may be difficult to locate data. Moreover, the software for a distributed LAN system is typically complex, occupies a lot of RAM, and may be inefficient (and thus, slow).

SOFTWARE OPTIONS

First things first. Five basic options are available for LAN software licensing, with many variations. The first option is for the vendor to license on a per-machine basis; that is, the user buys a copy of each type of software for each PC in a LAN. Although vendors continue to market this option, it is clearly unacceptable to users. The idea behind LANs, after all, is to share resources, and that should include software.

The second option is licensing on a per-network basis. Under such an arrangement, vendors may charge four to five times the single-user cost of the software, but then the licensee will have unlimited use. Microrim takes this approach with its R:base System V. A third option is to include the LAN in a corporate or site license enabling the users to have unlimited use of the software and produce an unlimited number of copies. The fourth method is to license software on a per-server basis; the software will operate only when installed on that particular server. Performance will dictate when another copy is required for a second or third server.

Perhaps the last option is the most acceptable: to have one license per network with a limit on the number of users on the network. One copy of the software is placed on the server, and a limited number of PCs can run the software at one time. Many vendors market a system after this blueprint, including Ashton-Tate with its dBASE III PLUS.

Many questions arise regarding the actual performance of LAN software: Does it have a file or a disk server? What is the degree of transparent multiuser support? How many active PCs are permitted (those using I/O), and are they application and time-of-day dependent? What is the maximum number of servers for the system? Does the network interface hardware contain direct memory access (DMA) and interrupt support? Does it have a VLSI (very large scale integration) coprocessor? What is the physical bandwidth and transmission speed? What are the packet sizes? Does the system use token-passing or CSMA (carrier sense multiple access)? (This becomes insignificant if the system is a typical PC with mixed I/O usage.) Will the network I/O be basically light, for applications such as program editing, word processing, spreadsheets, graphics, and electronic mail, or will it be moderate to heavy, for applications such as database searching and indexing, virtual print spooling, file transfer, assemblers, and compilers?

Server performance itself depends upon several factors: Is the server dedicated or nondedicated? Is it a custom server or a PC operating as a server? Is a multitasking operating system used? Are resident drivers included? This is something that is often hidden in the implementation of a LAN. A number of PC LANs patch, modify, and change DOS until it works in a DOS LAN environment. In other systems, such as Novell NetWare, the operating system does not depend on DOS for its operation. Indeed, a true multitasking operating system has nothing to do with DOS. The 3Com company is an interesting case in point. Before its current 3Com server, the company used a high-performance server called the AP Server. The AP was an Altos 586 machine running Microsoft XENIX.

In addition, the speed of a machine's hard disk can affect server performance. The average disk access time is approximately 30 milliseconds (ms), which is acceptable; however, some systems have disks that take 60, 70, 80 ms, or more. Although hundreds of accesses take place per second, these times add up quickly and affect performance substantially. This is the reason why some systems with very high-speed drives can access information very quickly and perform better in a multiuser environment where the server's hard disk has a lot of head movement.

Disk caching is important for keeping frequently used data in the file server at all times. Hashing, another feature important to server performance, allows the server to run path names through an algorithm and obtain a 16-bit or 32-bit hash code instead of a large path name. Thus, when a server moves to retrieve a file from a directory, it can look up the hash code in a table instead of the longer path name.

The number of concurrent operations on a system naturally will affect server performance. For example, the Novell system can run a print server and the file server on the same machine. The 3Com system can run electronic mail, a print server, and a file server, all on the same machine. The ability to queue incoming requests is also a consideration. Suppose the server is gathering data from the hard disk. Are all users to shut down at this time, or can the server continue to accept requests from the network packets while it is gathering data?

Some servers incorporate elevator seeking to optimize the ordering of requests and thereby minimize the head movement on a hard disk. The process is similar to that of an actual elevator: someone on the 18th floor presses a button for an elevator that is at ground


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level; as the elevator begins to go up, someone else wishes to get on at the 14th floor. The elevator picks up the person on the 14th floor on the way to the 18th floor. In LAN elevator seeking, the head picks up requests as it travels through the disk. A server that incorporates elevator seeking yields the best performance. (Single-user machines, such as the PC/XT and PC/AT, do not implement elevator seeking. Vendors who put their servers on top of an XT or AT system will have a major problem with head thrashing.)

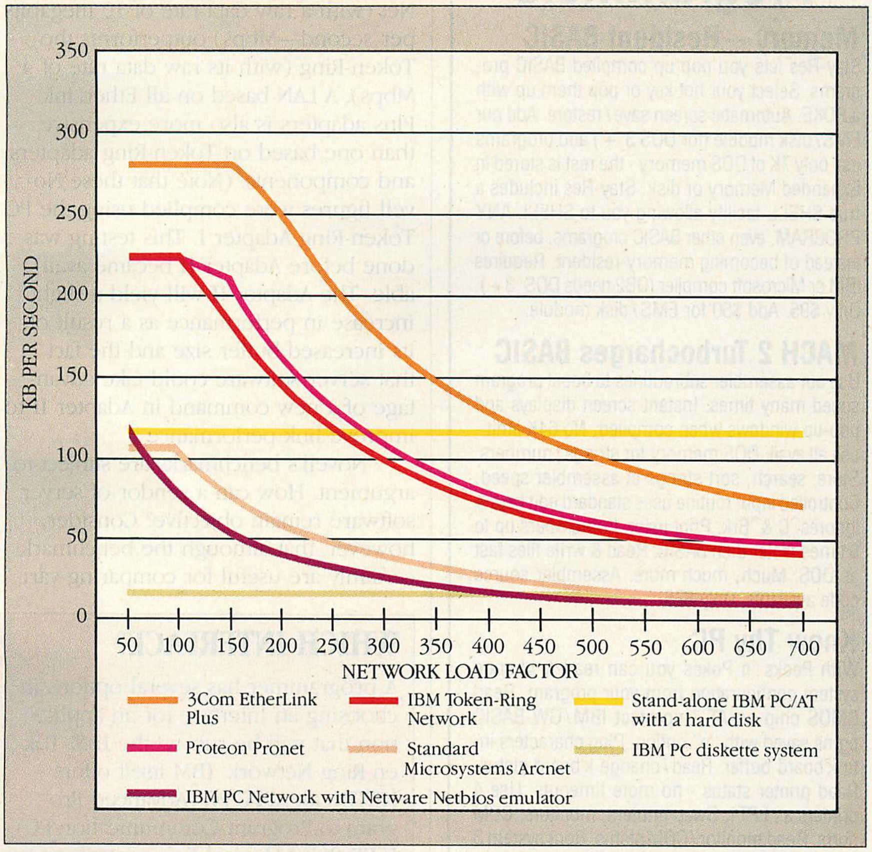
Benchmark reports on LAN environments frequently contain inherent fallacies. First, the number of PCs used in a benchmark network is generally too low (typically, fewer than six). This does not give a clear indication of how the system will work with 30, 40, 50 PCs, or more. And, as discussed, all servers are not the same—various models can be 10 to 100 times faster than others. Some benchmarks have been carried out using a server with a poor performance only because it was the least expensive. Another factor that benchmarks often do not take into account is the effect of keyboard interrupts, especially in IBM PCs. Typing on a PC keyboard generates low-level interrupts to the processor. If the PC is being used as a server, the user will constantly be interrupting the server process running in the background. This will affect performance significantly.

Other enigmas impair LAN benchmark reports: How can the reliability of a LAN environment actually be tested, and is that reliability based on the integrity of the software? In addition, some benchmarks try to make single-user software perform in a multiuser way. They may downgrade a network or a PC software vendor because it does not work in a multiuser LAN environment when the software was never designed for that in the first place. (Lotus 1-2-3 is often abused in this way.)

EARLY GRADES

The sample benchmarks included with this article are typical of those now being run on LANs. They were timed and measured by the respective companies (Novell and IBM); thus, they represent real, not simulated, results. They were chosen because they were designed to measure performance outright, not as a comparison among competitive vendors. Although they still say nothing about "typical" work environments, these data can be used as a rough gauge for response times. The Novell benchmarks run NetWare on different

FIGURE 1: *Novell NetWare System Profile*



The Network Load Factor is determined by considering the various types of users on the ring, assigning each a weight value, and adding them to produce a total.

LAN technologies. (For a full discussion of this software, see "NetWare in Control," Art Krumrey, November 1985, p. 102.) The IBM data represent raw throughput of the its PC Network Program under certain circumstances.

Novell's format. Novell has defined a LAN performance methodology called the NetWare Evaluation System. The idea is to determine the network load based on a profile of user types, then compare the result with various graphs to determine the best network/server configuration to meet that requirement.

The user types are ranked from 1 to 5, where 1 is a light-load user and 5 a full-load user. The load is defined as a bandwidth requirement for that user, based on an average maximum single-station throughput of 64KB/second (in reality, it ranges from a low of 17KB/second for an XT server on PC Network with the IBM NETBIOS to 174KB/second for an 8-Mhz AT-compatible Novell server on EtherNet using NetWare). Thus, a light load is about 3KB/second, and a full load is defined as 64KB/second (Novell points out that it is doubtful such an application exists—the 1 through 5 loads are not linear. For example, a type 4 user may be a heavy database operator with a 20 to 40 percent single-station throughput requirement, that is, 12 to 25KB/second.)

The load factor is obtained by multiplying the number of users by the user-type weight factor for each group, and adding the totals. For example, 10 users times a type 1 weight of 3 yields 30. Adding that to say, 8 users times a type 3 weight of 15, yields 150. If one type 4 user (at 40) is added, the total becomes 190 for an estimated network load. By comparing that number with Novell's Network System Profile (figure 1) for a standard IBM PC 6-MHz server operating with NetWare, a vertical line can be drawn at the 190 mark to see how the various LANs might perform under such a load. (Novell has included in this trial an AT with a hard disk and a diskette-based PC for comparison to stand-alone performance.)

The graph shows that three networks will turn in a better performance than the hard disk with a 190 load: 3Com EtherLink Plus, Proteon proNET, and the IBM Token-Ring. Note the convergence of the two Token-Ring networks to EtherLink Plus as the network

load factor increases. In terms of raw performance, the EtherLink Plus EtherNet (with a raw data rate of 10 megabits per second—Mbps) outperforms the Token-Ring (with its raw data rate of 4 Mbps). A LAN based on all EtherLink Plus adapters is also more expensive than one based on Token-Ring adapters and components. (Note that these Novell figures were complied using the PC Token-Ring Adapter I. This testing was done before Adapter II became available. The Adapter II will yield a slight increase in performance as a result of its increased buffer size and the fact that server software could take advantage of a new command in Adapter II to improve link performance.)

Novell's benchmarks are subject to argument. How can a vendor of server software remain objective? Consider, however, that although the benchmarks certainly are useful for comparing various LAN and PC technologies, they are not necessarily helpful in comparing servers. Performance is only one aspect of LANs to be considered, features and functionality are quite another. A common benchmark for performance, with some agreed upon weight factor for server functionality, would truly leave the choice to the user.

IBM endeavors. IBM has engaged in a number of studies to determine Token-Ring performance using the PC Adapter. For comparison purposes, IBM chose to perform the tests on the PC Network as well. The IBM numbers presented here are preliminary and are not guaranteed by IBM. (In testimony to the fact the arrival at a set of standards for PC LAN operation is still some time away, the accompanying sidebar, "Which Interface?" is a brief discussion of the several interfaces available in writing applications to function on a network.)

WHICH INTERFACE?

A programmer has several options in choosing an interface for an application that will be run on the IBM Token-Ring Network. IBM itself offers NETBIOS, APPC/PC (Advanced Program-to-Program Communication/PC), IEEE 802.2 (logical link control, or LLC, protocol), IEEE 802.5 (token-ring protocol), DISOSS (Distributed Office Support System, via personal services), 3270 (via the 3270 Emulation Program), and API/CS (Application Program Interface/CS via NetView/PC). Through third-party vendors, a user can obtain NETBIOS emulation from Novell, and Microsoft-compatible networks from Ungermann-Bass and 3Com Corporation. And, of course, an operating-system level interface is always possible through DOS.

System Network Architecture (SNA) is clearly IBM's strategic long-range network architecture (even though the European data processing community is pushing IBM to follow International Standards Organization protocols). IBM's SNA commitment is reinforced with the introduction of IBM NetView/PC and the now-established APPC/PC program. Offering SNA-based protocols and applications for the PC is one of the ways in which IBM can retain its market share of personal computers and support large host customers that have many PCs.

However, subsequent to the introduction of the IBM PC Network, which offered the first hope for a common thread to LAN software, writing to NETBIOS has become reasonably popular, especially in PC-only LANs. The NETBIOS emulator on the Token-Ring was developed primarily for compatibility with the PC Network and to transport PC-Network-developed applications to the Token-Ring Network. In addition, Microsoft (MS) networks also offer most of the features of NETBIOS (such as the redirector). But even though a user can obtain NETBIOS applications to communicate with the IBM System/36, System/370, and even the Series/1, the NETBIOS interface (and MS networks) should be considered temporary solutions for either PC-only LANs or LANs with mixed computers and applications (that is, with PCs, minicomputers, mainframes, and so on).

A safe approach would be to write multiuser applications for networks that require file and record locking, in keeping with DOS 3.x. For mixed IBM environments, APPC/PC and NetView/PC clearly are the long-term interfaces to which applications should be written. For writing systems and protocol software, it is safer to write procedures that follow the 802.2 LLC for two important reasons: to maintain compatibility with the latest IBM/IEEE 802.2 specification and to operate on top of IBM's Adapters or those that use the Texas Instruments chip set. This also will build in support for mixed IBM/other vendor 802.5-compatible token-ring LANs.

—J. Scott Haugdahl

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CIRCLE NO. 217 ON READER SERVICE CARD

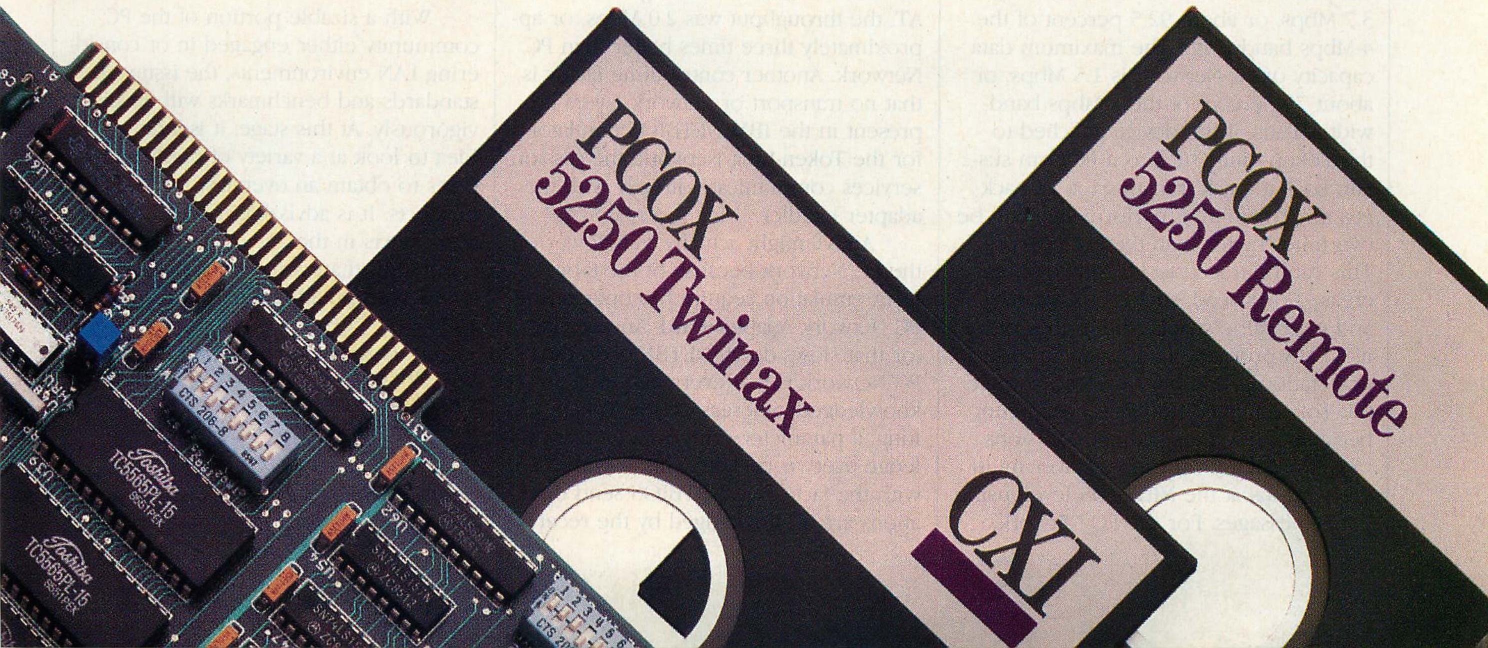
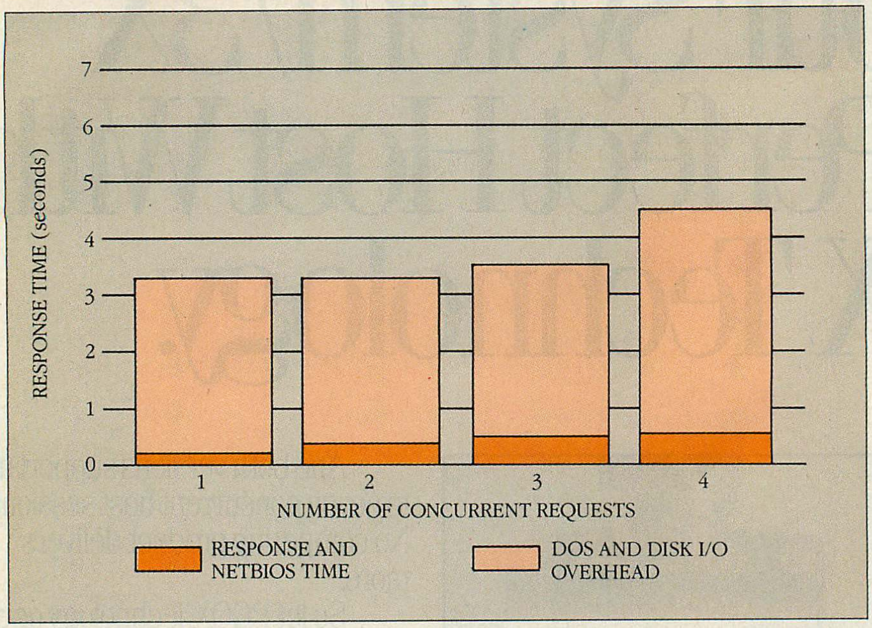


FIGURE 2: *IBM Network Response Times*



The response time will depend upon the time that is spent by the network station to service the request in and the time taken to transmit the data over the ring.

TABLE 1: *IBM Benchmark Results*

	LOGICAL LINK CONTROL	NETBIOS
40KB FILE LOAD FROM SERVER		
PC or PC/XT	< 8 percent	<20 percent
PC/AT	< 3 percent	< 8 percent
100KB FILE COPY FROM/TO SERVER		
PC or PC/XT	<21 percent	<59 percent
PC/AT	< 8 percent	<21 percent

The transfer of a large file on the PC takes a sizable percentage of the processor's time. It is unlikely that sufficient time is left for use by a multitasking system.

Assuming the network could be loaded with frames as close to 100 percent as possible, the Token-Ring can carry data (at the physical link level) at 3.7 Mbps, or about 92.5 percent of the 4-Mbps bandwidth. The maximum data capacity of PC Network is 1.5 Mbps, or about 75 percent of the 2-Mbps bandwidth. Thus, if the device attached to the Token-Ring (such as a PC) can sustain back-to-back transmission of packets, the Token-Ring performance will be two times better than the PC Network. This can be traced to PC Network's increased overhead, such as preambles and interframe spacing time present in its CSMA protocol. In a case where several stations were offering load at once, the Token-Ring would fare even better because it operates without collisions.

IBM measured capacity over multiple sessions at the NETBIOS level, using 16KB messages. For the PC Network, the maximum possible throughput at the session level was 650 kilobits per second. Using the Token-Ring with the NETBIOS emulator running in a 6-MHz AT, the throughput was 2.0 Mbps, or approximately three times better than PC Network. Another contributing factor is that no transport or network layers are present in the IBM NETBIOS emulator for the Token-Ring Network; the session services communicate directly with the adapter handler.

An AT might actually run slower on the PC Network because of the 8-bit DMA emulation required to operate the PC Network Adapter Card. Another factor that slows down NETBIOS on the PC Network is that every packet is acknowledged, whereas on the Token-Ring, a parameter can be set to acknowledge every *n* packets. This, together with the fact some NETBIOS send operations are acknowledged by the receiving station before the sender "completes" the operation, adds up to a fairly impressive performance.

IBM also determined that the maximum data rate of any one station on the Token-Ring depends on how fast the processor for that station is. For example, a single 6-Mhz AT can drive the network at nearly double the rate of a standard PC or XT.

"Real-world" tests were conducted by IBM using the Token-Ring with the NETBIOS emulator and the PC Network Program, and one AT that was configured as a dedicated file server. A 40KB file was loaded by one to four workstations. The response time exhibited by the workstations is illustrated in figure 2. The top portion of each bar is the time spent by the AT in servicing the request (mainly in fetching data from the hard disk). The bottom portion is the actual time spent transferring the data over the ring. As with all PC LANs, the response time will depend not only on the performance of the network, but also on how fast the server can service the request. Recall that file servers, for example, are limited by the speed of a system's hard disk. The bottom line in achieving optimum server performance is to use as much of the available LAN bandwidth as possible.

Another interesting way to measure performance is by the percentage of the PC's processor used while performing a network operation. This indicates the amount of "idling" (or time wasted) experienced by the processor in which a multitasking operation could be implemented. The results of the IBM study are listed in table 1. In general, to achieve optimal ring performance, regardless of the PC type, the user must maximize the buffers in each workstation and minimize the links between the workstations.

With a sizable portion of the PC community either engaged in or considering LAN environments, the issues of standards and benchmarks will develop vigorously. At this stage, it is a good idea to look at a variety of published reports to obtain an overview of available products. It is advisable to test individual products in the anticipated configuration rather than commit to a system based on reputation alone.

J. Scott Haugdahl is a senior systems specialist at Architecture Technology Corporation, a consulting, publications, and seminar firm specializing in data communications. Mr. Haugdahl has been researching the LAN industry for more than five years, designing products, writing papers and books, and presenting seminars on a world-wide basis.

LAN REPORT 5

A Hard Look at LAN Choices.

Novell's LAN Report Package makes choices easier.

The flexibility of local area networks allows users to assemble LANs using network components that best suit the needs of the installation. But choosing those components can be a confusing process.

Novell, Inc., has published two reports designed to make the process easier: the *LAN Operating System Report 1986* and the *LAN Evaluation Report 1986.*

These reports help users evaluate network components and make informed decisions when choosing the components that meet their needs. Hardware and software issues are separately evaluated in the two reports, and extensive performance benchmarks are included.

Software Choices.

Choosing a network operating system, or LAN software, is the most critical aspect of designing a network. Simply, the better the operating system, the better the network. The *LAN Operating System Report* contains an in-depth analysis of LAN software, beginning with an examination of LAN software standards such as MS-DOS 3.1 and NETBIOS, and the file server environment. Issues like internetworking, system reliability, security and performance are addressed as well.

The *LAN Operating System Report* also evaluates Novell Advanced NetWare, the IBM PC Network Program and 3Com 3+. The report shows users how the design and implementation of these products translates into real performance.

Hardware Options.

The *LAN Evaluation Report 1986* focuses on evaluating network hardware. It examines hardware issues that affect LAN performance, including an analysis and benchmarking of major LAN products.

"Hardware and software issues are separately evaluated in the two reports..."

A key element of the study is the NetWare Evaluation System. The system provides a mechanism for matching site needs to specific hardware. Whether a new network is being planned or an existing site is being upgraded, the study is useful in the performance evaluation of any network.

System planning starts with the network interface card (NIC) and cabling. NICs analyzed in the study are:

- AT&T StarLAN
- Corvus Omninet
- Davong MultiLink
- Gateway G-Net
- IBM PC Network
- IBM Token Ring
- Interactive Systems Vista LAN/PC
- Nestar PLAN 2000
- Novell S-Net
- Proteon ProNET
- Standard Microsystems ARCNET
- 3Com EtherLink
- 3Com EtherLink+

The report analyzes each NIC according to its access scheme, raw bit rate, on-board processor and NIC-to-host transfer method.

Another important component of the LAN is the network server. In examining network servers, the *LAN Evaluation Report* looks at several performance indicators. Processor type is the most obvious feature to differentiate servers. However, other factors important in determining server performance are also evaluated, including processor clock cycle speed, wait states, server memory cycle speed, memory channel and transfer bus channel. And the report examines the effect of disk channel speed on network performance.

In addition to providing a careful examination of LAN hardware, the *LAN Evaluation Report* features an evaluation formula. Using the formula, a LAN's estimated future site activity is measured and matched to the appropriate LAN hardware.

To Get the Reports.

The *LAN Operating System Report 1986* and the *LAN Evaluation Report 1986* are available free of charge from Novell. To obtain a copy of the Novell Report Package, call or write Novell Corporate Communications, 122 East 1700 South, Provo, Utah 84601, (801) 379-5900.

NOVELL

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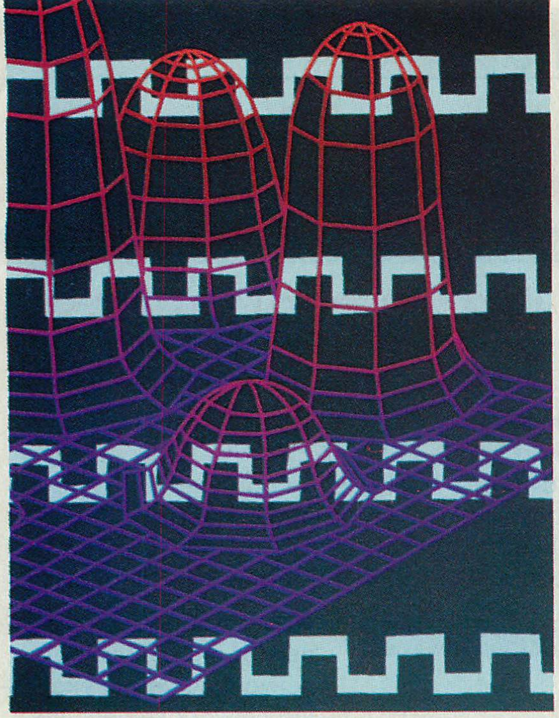

COMPUTER GRAPHIC • NATALE/EAST

Execution Profilers for the PC
Part 2

RALPH G. BRICKNER

To optimize a program's performance, a developer needs to discover the parts of the program that take up the most time. An execution profiler can be used to analyze a program, determining how much time the program spends performing various tasks. Sophisticated performance analysis of this type is available from the many commercial profilers.

Part 1 of this article (November 1986, p. 120) presented assembly language and Turbo Pascal code for a simple execution profiler, PRF. In Part 2, five commercial software packages are reviewed and compared with PRF. They include: Atron Corporation's SPTA (Software Performance and Timing Analyzer; David Smith Software's Code Sifter; dwb Associates' Profiler; Phoenix Technologies Limited's Pfinish; and Stony Brook Software's The Watcher. (For a comparison of features, see table 1.)

TESTING THE PROGRAMS

To evaluate the performance of these five products, three programs were used. SIN.EXE is a FORTRAN program that calculates the sine function by two methods; one uses its own Taylor's series approximation, and the other calls the FORTRAN intrinsic function SIN. SIN.EXE is included as a demonstration program with IBM Professional FORTRAN. For the purpose of these tests, SIN.EXE was compiled with IBM FORTRAN version 2.0, because it provides line number output to the linker for symbolic interpretation.

The second program, TERM.EXE, does interrupt-driven I/O to the COM1 serial port. The assembly language code first appeared in *PC Tech Journal* as DUMBTERM (see "Interrupts and the IBM PC," Chris Dunford, January 1984, p. 144). The only modifications that were made to the code were to include PUBLIC statements for all of the procedures so that the PROC names would appear in the .MAP file.

LOOPS.EXE, the third test program, is written in C and is provided with Code Sifter. This program consists of a series of nested loops that do simple assignments and some arithmetic computations. All three test programs have .MAP files to allow symbolic interpretation of the collected data.

Profilers employ one of two approaches to performance monitoring, passive and active. Some simple profilers use the passive approach. PRF is an example of this type; it does not modify the actual subject code. The passive type of monitor is restricted to an observational role, recording CS:IP (the segment and offset of the instruction pointer) at specified intervals. In addition to the capability of passively sampling CS:IP, the active-type profiler actually modifies subject code, inserting jumps to the profiler to count procedure calls and events and to turn timers on and off. Although these features are quite useful, there are trade-offs. Active profilers consume more memory resources, and it is possible to corrupt data that are not specifically excluded from active sampling techniques. Not surprisingly, the two active profilers, SPTA and Pfinish, come from vendors who also offer sophisticated symbolic debuggers; their execution profilers are part of a comprehensive line of debugging and performance monitoring tools.

Profilers save data in different ways. PRF, SPTA, and The Watcher simply save all the samples they collect, until the data table fills up or the subject program terminates. After collecting these data, the analysis portion of the

Commercial software profilers help developers identify and speed up the part of a program that consumes the most time.

profiler reads the data and interactively processes them to make its report. This approach allows the user to run the (possibly lengthy) subject code once and then formulate questions to ask the profiler in an iterative manner, without rerunning the subject. This also allows separate code to be used for sampling and analysis. Using separate sampling and analysis code saves on memory usage by the profiler. Profilers that combine both sample and analysis code tend to be rather large; SPTA, for example, requires more than 128KB by itself. A convenient feature that is found only in The Watcher saves samples to a permanent disk file. This allows the programmer to come back later to analyze the data.

Another significant issue in the design of profiling software is the provision for a macro or command file capability. Some of the more complex products require the user to enter a rather large number of instructions in order to exploit their flexibility. Therefore, the ability to save and retrieve these instructions becomes a necessity. The outstanding products in this area are SPTA that offers an interactive save-and-recall macro feature and Pfinish with a batch-like command file facility.

The presentation of data was nearly uniform across the product spectrum. As with PRF, the results are usually given in histograms. Some of the programs supported changing histogram parameters, such as minimum percentages to be displayed; some did not. They also differed in the amount of auxiliary information that was displayed, for example, address partition labels or actual address ranges, number of samples, individual bin percentages.

An important consideration in the reduction of the data is how the address ranges for the bins for accumulating counts are determined. In PRF, a list is kept of all distinct code segment register values found in the samples. A segment histogram is then displayed, showing the relative abundance of each segment in the samples. Next, each individual segment may be analyzed, with a histogram of offsets encountered within that segment. PRF is very address-driven, not symbolic; its model of segment-offset histograms closely matches the actual 8088 architecture.

Programmers tend to write in high-level languages and think in symbolic terms. Therefore, the ability to associate histogram bins with meaningful program symbols is very important. All of the reviewed products provide some support for symbolic interpretation of the results, using information obtained from the .MAP file produced by the DOS linker.

In practice, an enormous variation in the amount of information generated in the .MAP file will be encountered going from one language processor to another or from one program to another using a given language processor. Thus, significant questions in the analysis of these products' usefulness include: how robust are they in dealing with this information? What aids do they give the user for managing the information? How well are they able to distill the information to a useful basis for making software development decisions? A particularly useful feature is the ability automatically to assign symbolic regions to the physical address bins; the other option is manually to enter symbolic regions for the bins. A number of less important features are available that an individual product might offer. For example, convenient redirection of output to a printer or disk file, variation of the sampling rate, and variation of the data table size are all features of PRF, which may or may not be offered in the software that was reviewed.

The presentation of data was nearly uniform across the product spectrum. As with PRF, the results are usually given in histograms.

Atron Corporation. Atron's Software and Performance and Timing Analyzer (SPTA) is a complex, active-type profiler. It is an interactive, menu-driven program, although complex command streams may be defined as macros and saved to disk for later retrieval. Like the other reviewed products, it can statistically sample the code by means of a clock tick interrupt, the frequency of which may be selected by the user. For this mode of operation, however, SPTA stores a fixed number of samples. To vary the total amount of execution time that may be sampled, the user must change the timer frequency to an appropriate number.

Other functions available from SPTA include procedure duration measurement that determines the amount of time spent in a given piece of code, a program event counter that counts the number of times a given event occurs, and a procedure timing analysis that stores the times at which a given event occurs. SPTA is actually an enhancement to Atron's Software Source Probe debugger; consequently, a variety of auxiliary functions are available, such as unassemble, memory block moves, and a powerful macro capability.

Symbolically, SPTA handles public names and line numbers within a module (if they are present in the .MAP file). However, the user must manually assign the (symbolic) address limits to the 16 collection bins. Fortunately, collection bin limits are stored on disk symbolically and reconverted to addresses each time a new .MAP file is used. After setting up symbolic limits for LOOPS, SPTA produced the output shown in figure 1.

The demonstration program provided with SPTA can produce some real surprises if it is not used with care. The program is a small Pascal program that tests a region of system memory by writing to and reading values from it, beginning at an address entered by the user. The beginning address suggested in the documentation is 200K. Anything that happens to be in the memory region (including the performance analyzer or the demonstration program) will be overwritten by a test pattern. Users who employ terminate-and-stay-resident programs or execute programs from within a word processor or text editor must be careful about the region of memory they test with this program.

The documentation provided is well organized and indexed; a list of available commands is provided at the bottom of the command screen. Data analysis seems to take an unusually long time (1 minute and 5 seconds to plot approximately 8,000 samples). On the whole, SPTA seems to provide generous capabilities at a reasonable price.

David Smith Software. Code Sifter is a passive, monolithic profiler that does its data reduction in realtime. It is interactive and menu driven, and includes on-line help. The documentation is brief, but clear and well organized.

A unique feature of Code Sifter is an automatic repartitioning of the 32 sample bins. These bins are initially partitioned on the basis of the public symbols in the subject program's .MAP file in symbolic mode, or they are defined manually in terms of absolute addresses. After running the subject program, a quick press of F3 causes the code to discard the 16 least active bins and subdivide the remainder into 2, 4, 8, or 16 bins.

This repartitioning is done after every step when executing the subject program in the autorepeat mode. A few painless iterations of this procedure narrowed down the LOOPS program to its two most time-consuming subprograms (see figure 2). Note that LOOPS was provided with Code Sifter as a demonstration program.

An interesting feature of Code Sifter is that it automatically reads the .MAP file for the subject program, if present, and produces a sorted, condensed map file (.$MP) consisting of all public symbols. It then reads .$MP to set up the sample bins in symbolic mode. Unfortunately, this results in a loss of segment, group, and line number information, so that Code Sifter is not able to analyze SIN at the line number level. The large number of public names in the FORTRAN runtime code result in an uninformative session with the default .MAP file. When an edited version of the .MAP file that was created manually was used, Code Sifter was able to profile the execution times among the user-defined subprograms and the runtime code on the first iteration.

Another useful feature of Code Sifter is the ability to select any combination of user program, DOS, and BIOS code to include in the sampling, all with a single function key. This function is especially helpful when profiling TERM, because TERM executes a large number of DOS function calls. A few iterations on the partitioning and clock speed-up gave useful data on the TERM

TABLE 1: *Features Comparison*

	PCTJ SAMPLE	ATRON	DAVID SMITH	PHOENIX	DWB ASSOCIATES	STONY BROOK
Model	PRF.ASM	SPTA	Code Sifter	Pfinish	Profiler	The Watcher
Version	N/A	1.13	1.20	1.10	2.03	1.05
Price	N/A	$129	$119	$395	$125	$59.95
TYPE AND OPERATION						
Active profiler	○	●	○	●	○	○
Interactive	●	●	●	○	●	●
All samples saved for analysis	●	●	○	○	○	●
Separate sampling and analysis code	●	○	○	○	●	●
OUTPUT TYPES						
Histograms	●	●	○	●	●	●
Changeable histogram format	●	○	N/A	●	○	○
Summary statistics	●	●	●	●	●	●
PERFORMANCE MEASUREMENTS						
Timer ticks	●	●	●	●	●	●
Interrupts	○	●	○	●	○	●
Procedure calls	○	●	○	●	○	○
Stack tracing	○	○	○	●	○	○
Event counts	○	●	○	○	○	○
ADDITIONAL FEATURES						
Clock speed-up	●	●	●	●	○	○
Subject autorepeats	○	○	●	●	○	○
Output to printer	●	●	●	●	●	●
Output to file	●	●	●	●	●	●
On-line help	○	● [a]	●	○	● [a]	● [a]
ADDRESS REGION						
Absolute address	●	●	●	●	●	●
Address relocation	○	○	●	●	●	●
User definable	●	●	●	●	●	●
Automatic partition assignment	○	○	●	●	○	○
Automatic repartitioning	○	○	●	○	○	○
Symbolic	○	●	●	●	● [a]	●
SYMBOLIC SUPPORT						
Named segments	○	○	○	○	○	●
PUBLIC symbols	○	●	●	●	●	●
Line numbers	○	●	○	●	●	●
Autoread map file	○	○	●	○	○	●
Map file editing	○	●	● [b]	●	○	○

● = *Yes* ○ = *No*
N/A Not applicable

[a] *Rudimentary*
[b] *Done automatically*

All of these products offer some symbolic support, in addition to the basic functions that are required to analyze PC program performance.

program. (For information on clock speed-up for performance monitoring see part 1 of this article in November.) On the whole, Code Sifter provides all of the basic functions required to perform timer-tick performance analysis, along with its autopartitioning feature, at a reasonable price.

dwb Associates. Profiler, from dwb, is a passive, two-phase profiler. The first step in using the package is to execute the INSTALL program, which makes the sampling code (profiler driver) permanently resident in memory. The user then turns the sampling on and off by pressing the two Shift keys simultaneously. Unfortunately, this procedure is not fully compatible with Borland International's SideKick. While Ctrl-Alt always moves into and out of SideKick,

FIGURE 1: *SPTA Display*

```
Program terminated.  Termination code=0000
     Program Activity Measurement
     Sample rate is:  20.000 ms
  Min address      Max address      Count    % 0     20     40     60     80    100
0000:0000        ._MAIN+F08E         682    98 |*********************************
.MAIN            .MAIN+0117           22     3 |*
.COPYRIGHT       .COPYRIGHT+0458       0     0 |
3000:0000        3000:FFFF             0     0 |
.CSCLEAR         .CSCLEAR+0025         0     0 |
.CSENABLE        .CSENABLE+001D        0     0 |
.CSDSABLE        .CSDSABLE+05FB       57     8 |***
.STRCPY          .STRCPY+0029        298    43 |***************
.UPPER           .UPPER+0049           0     0 |
.STRCMP          .STRCMP+003C          0     0 |
.STRCAT          .STRCAT+0032        298    43 |***************
.SQRT            .SQRT+0117            1    <1 |
C000:0000        C000:FFFF             0     0 |
D000:0000        D000:FFFF             0     0 |
E000:0000        E000:FFFF             0     0 |
F000:0000        F000:FFFF            10     1 |*
                               Total:  196

ASm  ARange BP BYte COMpare CONsole DElete ECho EMacro EVal FIll FLag  Go   IF
INIt INTerrupt LIst LOAd     LOOp    MAcro  MEnu MODule MOVe NEst NOVerify  MORe
```

SPTA handles public names and line numbers within a module; the bin address limits must be assigned manually.

FIGURE 2: *Code Sifter Display*

```
AREA     COUNT  PERCENT         RANGE

USER      196     1.5   MAIN --> MAIN + 08B
USER      271     2.0   MAIN + 08C --> End of MAIN
USER      766     5.7   MY_SUBROUTINE --> End of MY_SUBROUTINE
USER      187     1.4   $ENTRY --> $ENTRY + 0F
USER       34     0.3   PRINTF --> End of PRINTF
USER      262     2.0   $DLOAD --> End of $DLOAD
USER       18     0.1   $DADD --> End of $DADD
USER       87     0.6   $DMUL --> End of $DMUL
USER      729     5.4   $DDIV --> End of $DDIV
USER        4     0.0   $DSTORE --> $DSTORE + 010
USER     2853    21.3   STRCPY --> STRCPY + 014
USER     2808    21.0   STRCPY + 015 --> End of STRCPY
USER     4821    36.0   STRCAT --> End of STRCAT
USER       13     0.1   SQRT --> End of SQRT
USER        4     0.0   FREXP --> End of FREXP
USER       33     0.2   FPUTC --> End of FPUTC
 Total Counts = 13396
     Press a key to return to MAIN MENU . . . .
```

The two most time-consuming subprograms in LOOPS are identified using the automatic repartioning of sample bins.

holding down both Shift keys results in an annoying alternating display: Profiler ON; SideKick; Profiler OFF; SideKick; Profiler ON; SideKick... Even without SideKick sharing the system, Profiler takes nearly a full second of holding down both Shift keys to switch on and off. Because the user must start and stop the sampling process without any knowledge of the internal state of the CPU's instruction stream, it is difficult to know what is being sampled. For accuracy and reproducibility, it would be clearer (although much harder to code) if a profiler adhered to a convention such as "Turn on sampling preceding EXEC call; turn off after return." In the tested version, Profiler does not know if a program is being loaded or if it is in the midst of running; it relies entirely on the user for that information.

Once the INSTALL code has been executed and is resident, PROFILER.EXE may be executed. This program is an interactive monitor that communicates with the resident code, telling it the address bin limits, resetting bin limits, and producing the output. The Profiler Monitor can be profiled by pressing Shift-Shift. As many as 16 address bins are intended to be set to the addresses of pieces of code in which the user is interested. The address limits on these bins must be set manually or Profiler does not perform as expected.

By default, Profiler's address bins are set to 0000:0000H - 0000:FFFFH, 1000:0000H - 1000:FFFFH, and so forth. The results of profiling the LOOPS program with this default range assignment are given in figure 3. Ranges for the address bins can be entered symbolically, because Profiler does read a .MAP file for symbolic information. However, after entering the limits symbolically, the ranges are converted to a numerical address and stored that way (assuming that the SAVE PARTITIONS function has been executed). These address regions become numerical offsets into the load module, which is assumed to be at segment 0000H. The documentation from dwb actually instructs the user to run DOS DEBUG to determine where the subject program is to be loaded into memory. Then the user must record the value and use function key F4 in Profiler to set a global CS (code segment) value to be added to all the absolute addresses. Because any program change results in a change in the absolute offsets of symbolic addresses, all the partition limits that have been laboriously entered will be invalidated whenever the code is changed.

Furthermore, any change in the operating system environment (such as loading a RAM disk driver) results in the user having to redetermine the global CS offset. During this review, after typing several lines of partition limits and saving them to a file, the LOAD PARTITION FILE function resulted in an "Invalid hex number in partition file" error message.

The documentation provided for Profiler is well organized and appropriate for the functions provided by the package. The program also offers some rudimentary on-line help.

Phoenix Technologies Limited. Pfinish is an extremely complex execution profiler of the active type. It is capable of generating statistical reports based on timer ticks and lists of callers of given regions, the number of instructions executed in a given region, the number of times overlays are loaded, and the number of times a region is entered. A rich and varied command language is provided to support these functions.

To use Pfinish, the programmer first must run a utility to append the .MAP file symbolic information to the end of the subject program's executable file. Pfinish commands can then reference symbols in the table. Next, a command file is prepared that tells Pfinish which symbolic (or possibly absolute) regions to INCLUDE in or EXCLUDE from the analysis, which reports to generate, and which modes to set. If a command file is not provided, histograms will be prepared by dividing the subject program into 256 equal regions. Then Pfinish is run, and the subject program is executed. Finally, the user examines the output file with a text editor (or redirects the output to the screen). Figure 4 is an example of the basic Pfinish output for LOOPS.EXE.

Pfinish has some idiosyncracies that make it somewhat difficult to learn to use. For example, to INCLUDE all the procedures in a given code segment for analysis, the user must specify "INCLUDE SEGMENT **proc_name**" in the command file instead of "INCLUDE SEGMENT **code_seg_name**". Here, **proc_name** is the name of some procedure in the desired segment, while **code_seg_name** is the name of the segment itself. As with most active pro-

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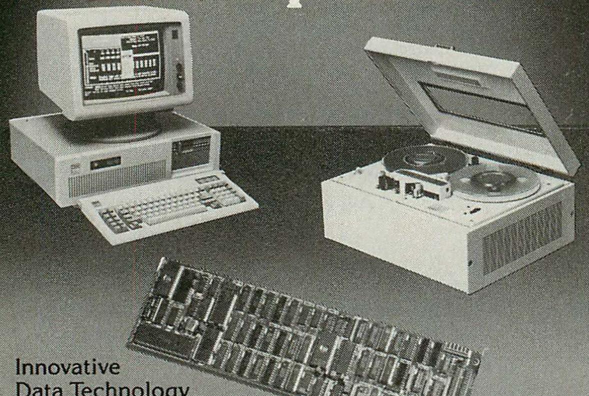

Innovative Data Technology offers a variety of 1/2 inch 9-track magnetic tape subsystems for the IBM-PC/XT/AT featuring the new "LEO" PC tape controller.

"LEO" is a state-of-the-art PC tape controller that lends itself to the most sophisticated applications including real time data acquisition, multitasking and true streaming disk back-up. "LEO" comes standard with an impressive list of features that include a dedicated microprocessor, up to 64K of RAM for buffering, high speed thruput with memory mapping I/O—no DMA channel required, ASCII to EBCDIC code conversion and external cable connectors for easy installation.

Supplied on a 5 1/4" diskette is the most comprehensive set of software drivers and utilities available. Users have a choice between an installable I/O driver with modules to "Basic" and "C" languages, or an MT-DOS device driver, which allows direct tape access under any language supported by DOS 3.1. Also included is "ANSI," a sophisticated file transfer utility, "TAP" a comprehensive disk back-up and restore utility and "TCMD" tape command, a valuable tool for inspecting tape data and format. All utilities are menu driven with help screens for user friendly operation.

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Eastern Regional Office:
One Greentree Center, Suite 201
Marlton, NJ 08053
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FIGURE 3: *Profiler Sample Output*

```
FUNCTION 6, DISPLAY PROFILE.
                    10%  20%  30%  40%  50%  60%  70%  80%  90%
                 ||----|----|----|----|----|----|----|----|----|----|
Partition 0      ||***************(31.73%)(112)
Partition 1      ||*********************************(66.01%)(233)
Partition 2      ||(0.00%)(0)
Partition 3      ||(0.00%)(0)
Partition 4      ||(0.28%)(1)
Partition 5      ||(0.00%)(0)
Partition 6      ||(0.00%)(0)
Partition 7      ||(0.00%)(0)
Partition 8      ||(0.00%)(0)
Partition 9      ||(0.00%)(0)
Partition a      ||(0.00%)(0)
Partition b      ||(0.00%)(0)
Partition c      ||(0.00%)(0)
Partition d      ||(0.00%)(0)
Partition e      ||(0.00%)(0)
Partition f      ||(1.98%)(7)
                 ||----|----|----|----|----|----|----|----|----|----|
                    10%  20%  30%  40%  50%  60%  70%  80%  90%  100%
Total samples taken = 353
Total samples hit   = 353
Partition hit ratio = 100.00%

(Horizontal bars have been converted to asterisks; underlines deleted.)
```

The information given using the default ranges for the 16 bins is of little use. Useful ranges must be entered manually.

FIGURE 4: *Pfinish .PRL Output File*

```
PFINISH COMMAND LINE : loops
 PROGRAM EXIT STATUS : Terminated normally
    PROGRAM RUN COUNT: 1
 LOWEST STACK POINTER: 100
PROGRAM RUNNING TIME: 00:00:24.45  445 ticks
  TOTAL RUNNING TIME: 00:00:24.45  445 ticks

              HIT COUNT
            +-------------------------------------------------------+
$DADD       |*                                                      | 0% 95
$DCEQ       |*                                                      | 0% 19
$DCLE       |*                                                      | 0% 20
$DCLS       |*                                                      | 0% 1
$DCVTL      |*                                                      | 0% 20
$DDIV       |*                                                      | 0% 76
$DLOAD      |**                                                     | 0% 556
$DMUL       |*                                                      | 0% 104
$DSTORE     |*                                                      | 0% 163
$ENTRY      |**********                                             | 8% 5001
$LMUL       |*                                                      | 0% 3
$MAIN       |*                                                      | 0% 1
CALLOC      |*                                                      | 0% 3
CLOSE       |*                                                      | 0% 3
CSCLEAR     |*                                                      | 0% 1
CSDSABLE    |*                                                      | 0% 1
EXIT        |*                                                      | 0% 1
FCLOSE      |*                                                      | 0% 3
FILENO      |*                                                      | 0% 4
FPUTC       |*                                                      | 0% 93
FREE        |*                                                      | 0% 3
FREXP       |*                                                      | 0% 19
LDEXP       |*                                                      | 0% 19
MAIN        |*                                                      | 0% 1
MALLOC      |*                                                      | 0% 3
MY_SUBROU   |**********                                             | 8% 5000
PRINTF      |*                                                      | 0% 4
SBRK        |*                                                      | 0% 3
SETMEM      |*                                                      | 0% 4
SQRT        |*                                                      | 0% 20
STRCAT      |***************************                            | 26% 15000
STRCPY      |*******************************************************| 53% 30065
SYSINT21    |*                                                      | 0% 4
WRITE       |*                                                      | 0% 4
_EXIT       |*                                                      | 0% 1
_FMTOUT     |*                                                      | 0% 4
_MAIN       |*                                                      | 0% 1
            +-------------------------------------------------------+
```

A command file tells Pfinish which regions of the program to analyze and which reports to generate.

CIRCLE NO. 108 ON READER SERVICE CARD

FIGURE 5: *The Watcher PLOT PROGRAM BY SYMBOL Output*

```
*Plot of program by symbol
from sample file LOOPS.IPS

MAIN            3.2%  |****
MY_SUBROUTINE   8.0%  |************

   .

$ENTRY          1.2%  |*
PRINTF          0.0%  |
$DLOAD          2.0%  |***

   .

$DMUL           0.8%  |*
$DDIV           4.8%  |*******
$FLOAD          0.0%  |
$FSTORE         0.0%  |
STRCPY         37.1%  |********************************************************
UPPER           0.0%  |
STRCMP          0.0%  |
STRCAT         34.7%  |****************************************************
SQRT            0.0%  |

   .

92.0% of the samples were included in this histogram.
```

The Watcher from Stony Brook Software claims to be able to generate histograms based on lines, symbols, and addresses, but, in fact, not all of the options worked.

filers, the user must instruct Pfinish to exclude data regions from its analysis to avoid corruption of data.

During testing, Pfinish refused to give statistics on timer tick samples, insisting that zero clock tick samples existed in the user program for SIN when no command file was specified. (It did perform satisfactorily when an appropriate command file was prepared, however.) Even worse, it froze the system when trying to analyze TERM (which admittedly accesses the interrupt controller chip directly) and required a system power-off to reset. This was after the data and stack segments were EXCLUDEd from analysis.

Of the reviewed products, only Pfinish and Profiler can analyze resident code. Once executed, Pfinish remains resident and collects data while the system goes about its business, until a separate utility is run to terminate the sampling and produce the report. The user is required, however, to reboot the system in order to return the occupied memory to DOS.

The documentation is quite lengthy; an index and detailed table of contents aid the user in locating information. Pfinish is expensive, but for the user who is willing to learn its idiosyncracies, it does provide a powerful profiling capability.

Stony Brook Software. The Watcher from Stony Brook is a passive profiler with separate sampling and analysis portions that communicate by means of a data file generated by the sampling program. The documentation provided is clear, well indexed, and not overly long.

The Watcher is a bare-bones profiler that does not include a clock speed-up feature, but it does offer reasonable symbolic support. It knows a program is composed of segments that are processed from various source modules, which have line numbers, and that code is distributed in memory by address. A histogram can be generated for a program, segment, or module, or for DOS interrupts. The Watcher can show sample counts for segments, lines, symbols, or addresses.

For example, users can plot the number of hits for the different segments encountered in a program, or they can plot the number of hits for line numbers in a source module. In fact, this method worked well in determining which subprograms LOOPS was spending its time in (see figure 5).

The Watcher was used to profile the execution of SIN and TERM without any problems. It had no trouble plotting the relative execution times in the public procedures in the code segment. However, it cannot plot a symbol (procedure name) by address, because that is not an allowed combination. Instruction-level profiling is only possible by means of the PLOT SEGMENT CODE BY ADDRESS command, which requires looking up the location of the procedure within the code segment in the assembler output listing.

The Watcher has only one useful command, PLOT, and a limited number of subvarieties of this command. The format of this command's output is fixed; all bins are shown even if they received no hits. The Watcher is reasonably priced; however, the amount of data entry required, along with The Watcher's nonautomated mode of operation, lessens its appeal.

FURTHER AUTOMATION NEEDED

A number of extremely powerful execution analysis tools are available to PC program developers, some at very reasonable cost. These tools can be quite useful in helping programmers to optimize code for maximum performance. While product characteristics vary widely, all of them offer, in principle, some symbolic support and the basic functions required to do a performance analysis. However, further automation of the analysis process is still necessary to free the programmer from the drudgery of needless data entry. Code Sifter and Pfinish represent the best solution to this problem, although neither is the final answer.

SPTA: $129.00
Atron Corporation
20665 Fourth Street
Saratoga, CA 95070
408/741-5900
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Code Sifter: $119.00
David Smith Software
Box 25A, RD #3
Oxford, NY 13830
607/843-6209
CIRCLE 353 ON READER SERVICE CARD

Profiler: $125.00
dwb Associates
7877 S.W. Nimbus
Beaverton, OR 97005
503/646-5607
CIRCLE 354 ON READER SERVICE CARD

Pfinish: $395.00
Phoenix Technologies Limited
320 Norwood Park S.
Norwood, MA 02062
800/344-7200
617/762-5030
CIRCLE 355 ON READER SERVICE CARD

The Watcher: $59.95
Stony Brook Software
Forest Road
Wilton, NH 03086
603/654-2525
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Ralph G. Brickner, Ph.D., is a researcher in parallel processing at Los Alamos National Laboratories, where he also performs benchmark tests on scientific computers.

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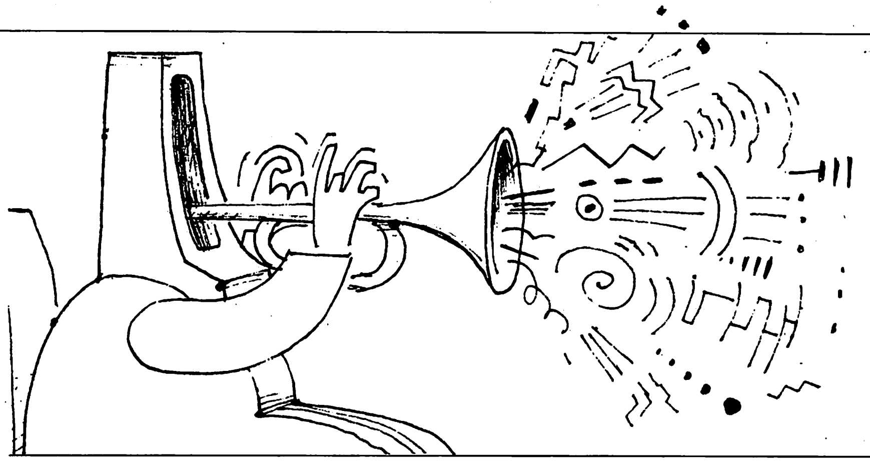
Creating Sound with the Timer

The PC's programmable interval timer devices can be used to generate a wide range of sounds.



Control of the sound system is one of the bigger omissions in the support services provided by DOS and BIOS. The PC timer can help make up for this lack. With the programs presented here, it can be used to generate a wide variety of sounds in the PC. The IBM PC, PC/XT, and PC*jr* contain the Intel 8253-5 programmable interval timer (PIT), and the PC/AT has an 8254-2 PIT; for all practical purposes, the two chips perform their functions identically. (IBM technical reference documents refer to the PIT as the *timer/counter* chip.)

All of the IBM PCs and ATs use a timer/counter input clock frequency of 1.19318 MHz. The 8253-5 can run at a maximum input clock rate of 2 MHz. The 8254-2 tops out at 10 MHz according to the Intel specification sheets, but IBM runs it at the same 1.19318 MHz rate. This indicates that the original design of the AT may have anticipated a higher timer clock rate, but IBM decided to maintain the same rate used in earlier PCs for compatibility reasons.

The highly compliant PIT contains three independent timer/counter channels. Each of the three timer/counter channels in the 8253-5 (and the 8254-2) PIT has the same design as summarized in figure 1. The external view of each channel shows a clock input, a gate lead, and an output lead. In addition, the entire chip has control registers and a data buffer. Each channel is programmed by writing a control word (actually a single byte) to port 43H, followed by a count, which is presented to port 42H as a sequence of two bytes.

At the core of each channel is a 16-bit, synchronous down counter, which can be preset. This *counting element* is surrounded by input and output buffering and control logic. On the input side of the counter is a pair of 8-bit registers (CR_M and CR_L) that form a 16-bit *count register*, which latches the count programmed by the CPU. The count is retained until it is reprogrammed.

On the output side of the counting element is another pair of 8-bit registers (OL_M and OL_L) that form the 16-bit *output latch*, which normally contains the same value as the counting element. Under CPU control, however, the output latch remembers the count at the time of a read request so that a stable value can be obtained. After the value has been read, the output latch is allowed to return once again to following the counting element.

The count register and output latch are each formed from two 8-bit registers so that the 16-bit counting element can be accessed over the internal timer/counter 8-bit bus, which is compatible with the external 8-bit data bus that is found in the PC.

Each counter/timer channel can be individually programmed for one of six modes (M0 through M5) of operation. (Refer to Intel's "Microprocessor and Peripheral Handbook," 1984, for programming details. Also, the article "Life in the Fast Lane," by Bob Smith and Tom Puckett, *PC Tech Journal*, April 1984, p. 62, contains a detailed introduction to the PIT chips and their use as moderately high-resolution timers.)

In a PC, channel 0 of the PIT is used to produce a regular timer interrupt at a frequency of approximately 18.2 interrupts per second, as shown in figure 2. A count of timer interrupts is kept in the BIOS data area of memory and is referred to as the BIOS time-of-day clock. At each occurence of the timer tick, interrupt 1CH is triggered, allowing a service routine to be installed that executes 18.2 times per second. This interrupt is at the core of many multitasking systems.

Channel 1 should not be tampered with because it is dedicated to RAM refresh. The gates to both channels 0 and 1 are tied electrically high (equivalent to a logical 1) so that the counters are free running at all times and cannot be disabled by software.

Channel 2 is part of the PC's audio subsystem. The components of the audio system are highlighted in figure 2. The counter gate is controlled by bit 0 of an 8255 programmable peripheral interface (PPI) device. The output of channel 2 and bit 1 of the PPI are logically ANDed together and fed to the audio driver circuit. The output of the driver is fed to the speaker through a low-pass filter. This channel can be programmed in a variety of ways in order to produce sound.

SOUNDING OFF

The C routines presented here provide a basic level of audio support for the PC. Combined with machine-indepen-

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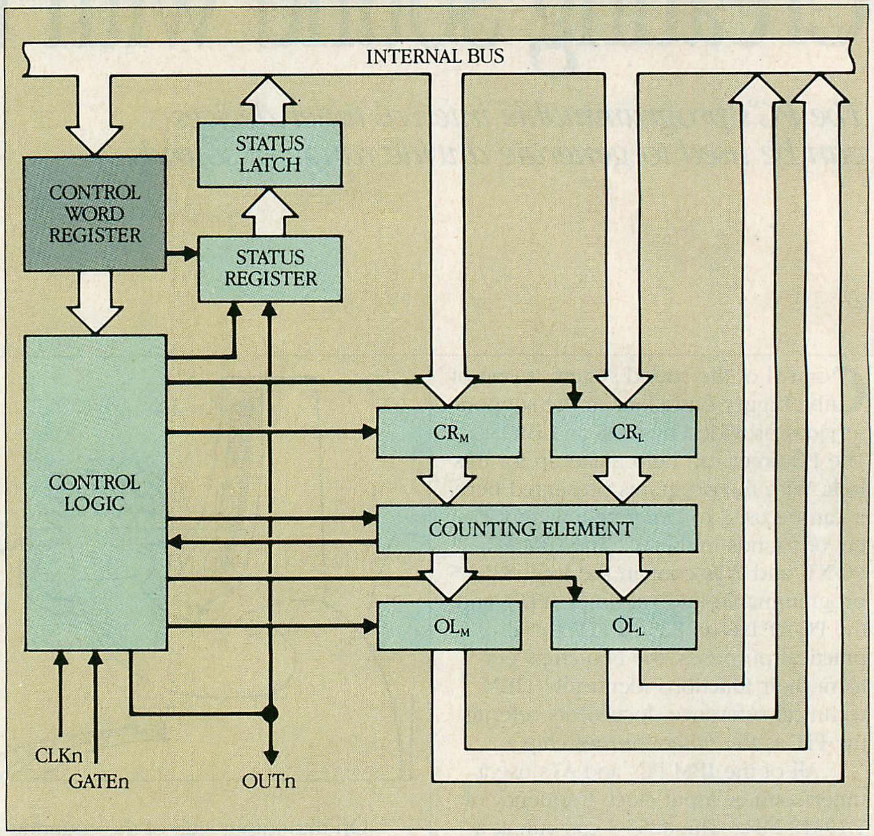
CIRCLE NO. 148 ON READER SERVICE CARD

FIGURE 1: *A PIT Counter Channel*



The PIT chip has only one control word register that is shared by all three channels (which are selected by two channel-select bits in the register). Channel status is also queried by presenting a command to the control word register.

dent time delays, these functions and macros permit a wide range of audible sounds to be generated by the PC's rudimentary sound system.

The aim of these programs is to generate tones that run in the background. The tones' frequencies are derived from the timer/counter clock, not from any output of the CPU, so their pitch is not controlled by the CPU and will be completely independent of any activity in which it is engaged.

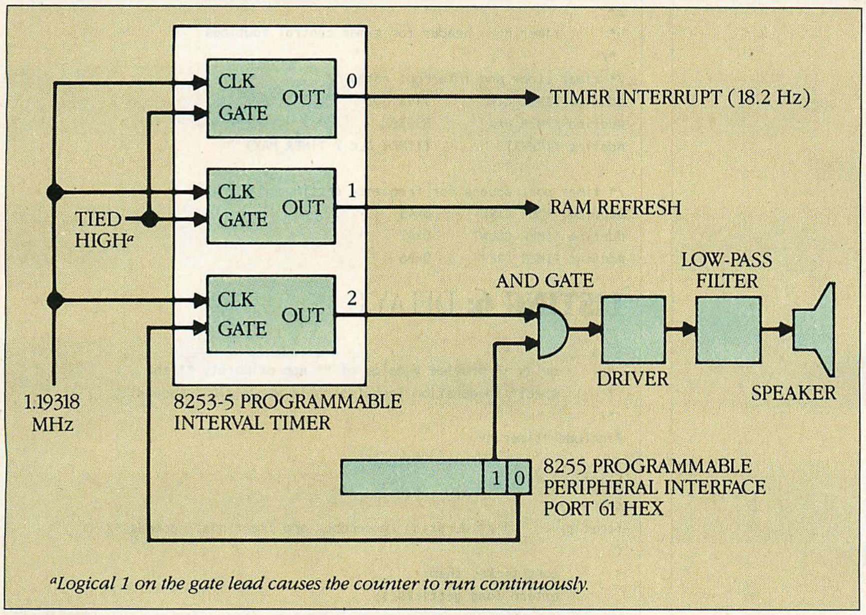
The SPKR program, composed of SPKR.C (listing 1) and SOUND.H (listing 2), allows the speaker to be turned on and off from the DOS command line or from batch files. Invoking SPKR ON (any argument in place of ON will work, too) turns the PC's speaker on. Invoking SPKR without any argument turns the speaker off.

The speaker-control macros, SPKR_ON and SPKR_OFF (defined in SOUND.H), control the state of bits 0 and 1 of port 61H in the 8255 PPI chip (see figure 2). When both bits are set to logical one, achieved by ORing the current value of port 61H with 03H, the audio system passes the signal from the channel 2 timer/counter to an amplifier and low-pass filter and then on to the speaker. When either (or both) bits 0 and 1 in port 61H is a logical zero, sound is turned off. This is accomplished by the macro SPKR_OFF, which ANDs the current value in port 61H with FCH, the bitwise complement of 03H. This sets bits 0 and 1 to 0 and leaves all other bits undisturbed.

SPKR allows the user to turn sound on and off, but gives no control over the pitch of the tone emitted by the speaker. The TONE program, consisting of TONE.C (listing 3), SETFREQ.C (listing 4), and TIMER.H (listing 5), selects the frequency by setting the count value in channel 2 of the PIT. TONE accepts a single command-line argument (the desired frequency in Hertz), converts the character form of the argument to an integer, and calls **setfreq**.

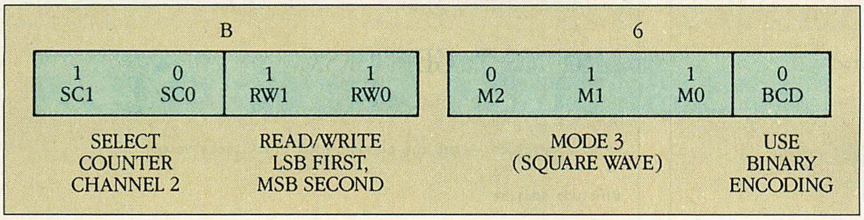
The **setfreq** function uses the values defined in the TIMER.H header file to set mode and counter values of PIT channel 2. The TIMER_PREP constant is interpreted as shown in figure 3. The value to be placed in the PIT channel 2 count register is the divisor needed to

FIGURE 2: *The PC Sound System*



Sound can be turned on and off in two ways. The channel 2 timer can be gated on or off by using its gate input, or the timer can be allowed to run freely, and timer output can be passed to the speaker or blocked by the AND gate.

FIGURE 3: *TIMER_PREP's Bit Fields*



Although the PIT supports six modes through mode bits M0-M2, only mode 3 (square wave) is useful in generating sound through the PC's speaker.

produce the desired frequency by the formula (timer clock rate / desired frequency). The counter is programmed by writing the TIMER_PREP value to the control port (TIMER_CTRL), followed by the least significant byte (LSB) and finally the most significant byte (MSB) of the divisor.

BEYOND BEEPS

Turning the speaker on and off and setting the pitch is only part of the requirement for a useful package. The duration of tones must be controlled in a machine-independent way so that changes in processor clock speed and processor loading do not affect the sound being produced.

The use of timing loops, which depend directly on the execution times of instructions, does not work. If the CPU clock crystal is changed, then the duration of a sound also is changed. Instead, the duration should depend on the timer tick (18.2 times per second) or something else that is regular and unaffected by machine type and CPU clock speed. These programs use the timer tick as its CPU-independent reference.

The constants TIMER_MAX and TICKRATE in TIMER.H are used by the second part of the sound-generation package. The **delay** function in DELAY.C (listing 6) takes a floating-point number of seconds and fractional seconds as a parameter and converts it to a long integer (**ticks**) that is the equivalent number of BIOS timer ticks. The **getticks** function in GETTICKS.C (listing 7) is called to get the current tick count from the BIOS time-of-day (TOD) clock count stored in the BIOS data area. This number is added to the number of delay ticks to get the count for the future time (**then**) that marks the end of the desired delay period. Then **delay** repeatedly queries the TOD clock until the returned value equals or exceeds the number stored in **then**, thus producing the required delay within about 55 milliseconds, which is the resolution of the timer tick.

Combining tone generation and delays produces a **sound** routine that behaves as the BASIC SOUND statement. The source for **sound** is in SOUND.C (listing 8). A frequency and a duration are specified. The function sets the specified frequency by calling **setfreq**, turns the speaker on, calls **delay** with the specified duration argument, and then turns the speaker off. The demonstration program in SOUNDS.C (listing 9) contains four examples of audible signals that can be produced by making **sound** function calls with different arguments in various combinations.

Recreating the executable files from the several source files presented here requires a fair number of compile and link operations. MAKEFILE (listing 10) is used by MAKE (a utility that is provided with many C compilers) to control the compiling and linking of the SPKR, TONE, and SOUNDS programs along with the various modules of the sound package. Another file called TOOLS.INI (listing 11) contains inference rules for use by the MAKE utility. With MAKE as provided with Microsoft C 4.0, it should be invoked as:

```
MAKE MAKEFILE
```

with the various source files in an accessible directory. If MAKE is not available, use the text of MAKEFILE as a guide to compiling and linking.

With little or no DOS or BIOS support, the PC sound system must be manipulated by working very close to the hardware. This raises the possibility that future generations of PCs will implement the sound system differently, and the routines presented here may become inoperative. The best defense, as always, is to understand the PC's timers and the different ways they may be applied, so that sound control software may evolve with the PC's sound generation hardware in a relatively painless way. In the overall design scheme, sound may not be the most important aspect of a computer, but when used well, it adds that extra touch of excellence to a good user interface.

Augie Hansen is the owner of Omniware, a Denver-based consulting and training firm that specializes in DOS and UNIX topics. This article is based on material presented in his most recent book, Proficient C, *soon to be published by Microsoft Press.*

LISTING 1: SPKR.C

```
/*
 *	spkr -- turn speaker ON/OFF
 *
 *		no args => OFF
 *		any arg(s) => ON
 */
#include "sound.h"

main(argc, argv)
int argc;
char **argv;
{
	/* turn speaker on or off */
	if (argc == 1)
		SPKR_OFF;
	else
		SPKR_ON;
	exit(0);
}
```

LISTING 2: SOUND.H

```
/*
 *	sound.h -- header for sound routines
 */
#define PPI		0x61
#define SPKR		0x03
#define SPKR_ON		outp(PPI, inp(PPI) | SPKR)
#define SPKR_OFF	outp(PPI, inp(PPI) & ~SPKR)
```

LISTING 3: TONE.C

```
/*
 *	tone -- set the frequency of the sound generator
 */
#include <stdio.h>

main(argc, argv)
int argc;
char **argv;
{
	extern void setfreq(unsigned int);
	if (argc != 2) {
		fprintf(stderr, "Usage: tone hertz\n");
		exit(1);
	}
	/* set the frequency in Hertz */
	setfreq(atoi(*++argv));
	exit(0);
}
```

LISTING 4: SETFREQ.C

```
/*
 *	setfreq -- sets PC's tone generator to run
 *	continuously at the specified frequency
 */
#include <conio.h>
#include "timer.h"

void
setfreq(f)
unsigned f;	/* frequency in Hertz (approximate) */
{
    unsigned divisor = TIMER_CLK / f;

    outp(TIMER_CTRL, TIMER_PREP);		/* prepare timer */
    outp(TIMER_COUNT, (divisor & 0xFF));	/* low byte of divisor */
    outp(TIMER_COUNT, (divisor >> 8));		/* high byte of divisor */
}
```

LISTING 5: TIMER.H

```
/*
 *	timer.h -- header for timer control routines
 */
/* timer clock and interrupt rates */
#define TIMER_CLK	1193180L
#define TIMER_MAX	65536L
#define TICKRATE	(TIMER_CLK / TIMER_MAX)

/* timer port access for frequency setting */
#define TIMER_CTRL	0x43
#define TIMER_COUNT	0x42
#define TIMER_PREP	0xB6
```

LISTING 6: DELAY.C

```
/*
 *	delay -- provide a delay of ** approximately ** the
 *	specified duration (resolution is about 0.055 second)
 */
#include "timer.h"

void
delay(d)
float d;	/* duration in seconds and fractional seconds */
{
	long ticks, then;
	extern long getticks();

	/* convert duration to number of PC clock ticks */
	ticks = d * TICKRATE;
	/* delay for the specified interval */
	then = getticks() + ticks;
	while (1)
		if (getticks() > then)
			break;
}
```

LISTING 7: GETTICKS.C

```
/*
 *	getticks -- get the current BIOS clock ticks value
 */
#include <dos.h>

#define TOD		0x1A
#define READ_COUNT	0
#define TICKS_PER_DAY	0x01800B0L

long
getticks()
{
	long count;
	union REGS inregs, outregs;

	/* get BIOS time of day as no. of ticks since midnight */
	inregs.h.ah = READ_COUNT;
	int86(TOD, &inregs, &outregs);
	/* correct for possible rollover at 24 hours */
	count = (outregs.h.al != 0) ? TICKS_PER_DAY : 0;
	/* add current day ticks */
	count += (outregs.x.dx + (outregs.x.cx << 16));

	return (count);
}
```

LISTING 8: SOUND.C

```
/*
 *	sound -- produce a constant tone for a specified duration
 */
#include <conio.h>
#include "sound.h"

void
sound(f, dur)
unsigned int f; /* frequency of pitch in Hertz */
```

```
float dur;      /* in seconds and tenths of seconds */
{
        extern void setfreq(unsigned int);
        extern void delay(float);
        /* set the frequency in Hertz */
        setfreq(f);
        /* turn the speaker on for specified duration */
        SPKR_ON;
        delay(dur);
        SPKR_OFF;
}
```

LISTING 9: SOUNDS.C

```
/*
 *      sounds -- make various sounds on demand
 */
#include <stdio.h>
#include <conio.h>
#include <math.h>

#define ESC     27

extern void sound(unsigned int, float);

main()
{
        int ch;

        fprintf(stderr, "1=warble 2=error 3=confirm 4=warn\n");
        fprintf(stderr, "Esc=quit\n");
        while ((ch = getch()) != ESC)
                switch (ch) {
                case '1':
                        warble();
                        break;
                case '2':
                        error();
                        break;
                case '3':
                        confirm();
                        break;
                case '4':
                        warn();
                        break;
                }
        exit(0);
}
#define CYCLES  3
#define LOTONE  600
#define HITONE  1200
#define PERIOD  0.1

warble()
{
        int i;

        for (i = 0; i < 2 * CYCLES; ++i)
                if (i % 2)
                        sound(LOTONE, PERIOD);
                else
                        sound(HITONE, PERIOD);
}
error()
{
        float d = 0.1;
        sound(440, d);
        sound(220, d);
}
confirm()
{
        float d = 0.1;

        sound(440, d);
        sound(880, d);
}
warn()
{
        float d = 0.2;
        sound(100, d);
}
```

LISTING 10: MAKEFILE

```
# makefile for time delay and sound routines

# --- timing and sound functions ---
delay.obj:      delay.c timer.h
getticks.obj:   getticks.c
setfreq.obj:    setfreq.c timer.h
sound.obj:      sound.c sound.h
sounds.obj:     sounds.c
spkr.obj:       spkr.c sound.h
tone.obj:       tone.c

# --- demonstration programs ---
sounds.exe:     sounds.obj sound.obj
        link $* sound delay getticks setfreq;
spkr.exe:       spkr.obj
        link $*;
tone.exe:       tone.obj
        link $* setfreq;
```

LISTING 11: TOOLS.INI

```
[make]

.c.obj:
        msc $*;
```


80386

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In order to help those people applying for these guaranteed and direct loans fill out their loan applications the "right way" our business researchers, with their diligent compilation and effective efforts, have successfully assembled and published a comprehensive, easy-to-follow seminar manual: The Business Opportunity Seekers' Loans Manual, that will **quickly show you practically everything you'll need to know** to prepare a loan application to get federally Guaranteed and Direct Loans.

Here are just **some of the many important benefits** the Business Opportunity Seekers' Loans Manual provides you with:

- **a completely filled in sample set of actual SBA loan application forms, all properly filled in for you to easily follow—aids you in quickly preparing your own loan application the right way. Each line on the sample application forms is explained and illustrated in easy-to-understand language.**
- **fast application preparation procedures for getting loans for both new start up business ventures and established firms.**
- **advises you on how to properly answer key questions necessary for loan approval and in order to help avoid having your application turned down—gives you advice on what you should not do under any circumstances.**
- **what simple steps you take to guarantee eligibility—no matter if you do not presently qualify.**
- **where you can file your application for fastest processing.**

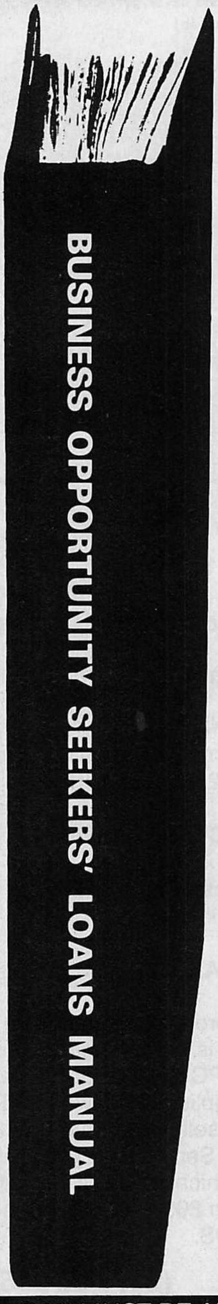
At this point the most important question you want answered is: Just where is all this loan money coming from? Incredible as it may sound—these Guaranteed Loans, Direct Loans...and Immediate Loans are indeed available right now — from the best, and yet, the most overlooked and frequently the most ignored and sometimes outright ridiculed "made-fun-of" source of ready money fast capital, in America — THE UNITED STATES GOVERNMENT.

Of course, there are those who upon hearing the words "UNITED STATES GOVERNMENT" will instantly freeze up and frown and say

"... only minorities can get small business loan money from the government!"

Yet on the other hand (and most puzzling) others will rant on and on and on that

"... don't even try, it's just impossible — all those Business Loans Programs are strictly for the Chryslers, the Lockheeds, the big corporations, not for the little guy or small companies" etc.



Still there are those who declare:

"...I need money right now...and small business government loans take too darn long. It's impossible to qualify. No one ever gets one of those loans."

Or you may hear these comments:

"...My accountant's junior assistant says he thinks it might be a waste of my time!" "Heck, there's too much worrisome paperwork and red tape to wade through."

Frankly — such rantings and ravings are just a lot of "bull" without any real basis — and only serve to clearly show that lack of knowledge ... misinformation ... and not quite fully understanding the UNITED STATES GOVERNMENT'S Small Business Administration's (SBA) Programs have unfortunately caused a lot of people to ignore what is without a doubt — not only the most important and generous source of financing for new business start ups - and existing business expansions in this country — but of the entire world!

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- **What SBA recognizes as a "small business" actually applies to 97% of all the companies in the nation**
- **Red tape comes about only when the loan application is sent back due to applicant not providing the requested information...or providing the wrong information**
- **The SBA is required by Congress to provide a minimum dollar amount in business loans each fiscal year in order to lawfully comply with strict quotas. (Almost 5 billion this year)**

Yet, despite the millions who miss out — there are still literally thousands of ambitious **men and women nationwide** who are properly applying — being approved — and **obtaining sufficient funds** to either start a new business, a franchise, or buy out or expand an existing one. Mostly, they are all just typical Americans with no fancy titles, who used essentially the **same effective know-how** to fill out their applications that you'll find in the Business Opportunity Seekers' Loans Manual.

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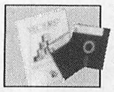

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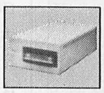
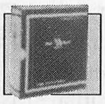


ADIC MODEL TD 440
ADIC



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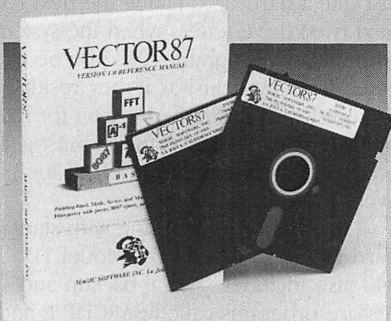

CIRCLE 349 ON READER SERVICE CARD

Combining the assembly language routines in Magic Software's VECTOR87 library with interpreted Microsoft BASICA is like bolting a 100-horsepower motor on a dingy. Taking a 1,024-point Fast Fourier Transform in 2.5 seconds with interpreted BASIC is positively neck-snapping. VECTOR87's package of 312 optimized assembly language routines provide lightning-fast, accurate vector and matrix manipulations. The minimum requirements for using the VECTOR87 library are an 8087 or 80287 numerical coprocessor in an IBM PC or PC/AT machine with at least 256KB of RAM and two diskette drives. The routines are not copy protected.

VECTOR87 offers a huge variety of single- or double-precision vector and matrix manipulations from a single-line CALL statement. It can be used to solve linear systems of equations, invert matrices, take fast Fourier transforms, evaluate transcendental and hyperbolic functions and their inverses in real or complex form, find histograms, do table look-ups, calculate mean square roots, generate arrays of random numbers, and evaluate polynomials. VECTOR87 also can perform a wide variety of complex vector and matrix manipulations, logical operations and comparisons, Cartesian to polar conversions, and more.

The first step in using VECTOR87 is to enter BASICA/M:,&H2000 at the DOS prompt. This reserves room for the assembly language routines outside of the BASICA code segment so that the BASIC source code can still occupy as much as 64KB of RAM. The BASIC source code then can be written—defining the desired precision, declaring all subroutine parameters, and, finally, CALLing upon any of the needed library functions with a single line of BASIC with a sensible and clear syntax. The application source code then is merged with a provided VECTOR87 BASIC source file. When the completed program is run, all essential assembly language code containing all of the necessary assembly code interface is BLOADed by one GOSUB call that is provided with the package.

The documentation is well written and clearly indexed. The system includes BASIC program examples that call each VECTOR87 subroutine at least once. Several Turbo Pascal programs also are included so that users with Turbo-87 Pascal can compile them and compare their execution times with the corresponding VECTOR87 demos. Generally, the demos execute 20 to 50 percent faster than similar code written in Turbo-87 Pascal. This percentage is a bit misleading because it does not contain some of the interpreted BASIC sections of code that may be necessary.

This package is not a set of general-purpose numerical analysis routines, but one that focuses on vector and matrix manipulations. For example, to evaluate an integral numerically, to find the roots to a function, or to integrate a differential equation, these routines must be built from scratch. Even if some of the primitives from VECTOR87 can be used, the user usually will have to perform some of the calculation with interpreted BASIC alone, which loses much of the performance gains realized from the assembly language routines. This is especially a problem because interpreted BASIC uses a format different from the IEEE real-number format used by the 8087. Also, because VECTOR87's machine code functions cannot call one another, control must return to interpreted BASIC after each function call. In applications that must execute a great many of the function calls, performance may lag significantly behind the performance of a Turbo-87 Pascal program written to accomplish a similar task.

For all its power, serious problems arise in using vectors, which require a cold reboot to ultimately escape. The worst problems come from the nonexistent error trapping for calls to the assembly language routines. Each routine requires strict type-assignment; only variables (not constants) can be passed to subroutines, and all parameters must be initialized before they are passed, even if the initialization is equal to 0, as BASIC does by default. No error messages occur if any one of these constraints is violated or if a subroutine that was not previously BLOADed is called. The manual says, "As these functions operate outside the environment and protection of BASIC, it is entirely up to you to ensure that the parameters in the CALL list match the number, type, and length with the parameters expected by the VECTOR87 function. Any mismatch here will cause the operating system to 'crash.' This should be easy to ascertain as BASIC will likely fail to respond to keyboard commands." Obviously, a crash is "easy to ascertain" when a cold reboot is required.

There are no return codes to indicate whether a routine has been completed properly or not. Truly nefarious problems happen when errors are silently generated and all seems well—a

situation that occurs all too easily. For example, if the user tries to invert a matrix and fails to set a calling parameter that specifies the number of arrays in a vector of arrays, BASIC will initialize the parameter to equal 0—a meaningless value in this context. The matrix inversion routine then just quietly generates errors and returns meaningless values as if nothing is wrong.

The same silent generation of errors occurs when the user attempts to invert a singular matrix—one with a determinant equal to 0 and, hence, no inverse. The routines do not check to see if the array subscripts are within bounds. Once again, the manual states, "Overrunning array bounds, particularly when storing data to memory, will generally crash the system at best or at worst give you no indication of a fault but wrong answers and perhaps a BASICA interpreter that doesn't work correctly!" This wild behavior is rationalized in the manual with the statement, "VECTOR87 does not check subscripts against bounds and gives you back that time for number crunching. The price you pay for this added speed is that VECTOR87 leaves it to you to manage your own data resources." Anyone with programming experience knows this is completely false economy. Only small amounts of code and execution overhead are required to check for reasonable input parameters and index array bounds. Then the user is free from any uncertainty and many hours of frustrating debugging as well.

Debugging BASIC with VECTOR87 code is extremely frustrating. For example, although BASIC automatically initializes all variables to 0, if the user does not explicitly initialize the determinant of the matrix (found as part of the inversion algorithm) to 0 before calling the matrix inversion routine, the system locks. Interpreted BASIC permits easy coding and debugging, even if the BASIC editor seems painful by modern standards. With the unruly assembly language routines from VECTOR87, however, frequent crashes occur without a clue as to the cause.

Until the error trapping and debugging improves, VECTOR87 cannot be recommended. Anyone desiring serious numerical analysis should get one of the good standard compilers on the market and a set of numerical analysis routines. Although useful work can be accomplished with VECTOR87's fast routines, the development process often is more difficult than it should be.

—VICTOR MANSFIELD

ADIC MODEL TD 440 DATA CARTRIDGE TAPE SYSTEM

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206/881-8004

PRICE: $1,595

CIRCLE 351 ON READER SERVICE CARD

The ADIC Model TD 440 Data Cartridge Tape System is a miniature version of ADIC's Model 552, which was reviewed in "Moving Up To Tape" (Steven Armbrust and Ted Forgeron, November 1985, p. 63). While the Model 552 is as large as the typical computer's system unit, the Model TD 440 measures only 10 inches by 6 inches by 3.25 inches and can be easily squeezed onto a crowded desktop.

This unit's small size is attributable to its tape format. Instead of using 5¼-inch cartridge tapes, the Model TD 440 uses the new 3M 3-inch DC2000 minitapes. On each of these tapes, the Model TD 440 can store 40MB of data. If this is not enough, a backup session can be split across multiple tapes.

The tape drive plugs into an SCSI (Small Computer Systems Interface) controller, a half-size card that can fit in the short slot of a PC/XT. Installation is simply a matter of inserting the card and connecting the cable, although the DMA channel used for tape operations can be changed via jumpers, if the default channel (2) conflicts with other hardware in the user's system. An addition to the CONFIG.SYS file is all that is needed to make the drive ready to use.

Like other ADIC units, the Model TD 440 sacrifices speed for data integrity. For example, each time a new tape cartridge is inserted, the drive spends between one and two minutes performing electrical and mechanical alignments. During this time, the drive rewinds the cartridge, sets the amplifier gain control, retensions the tape, realigns the head in reference to the edge of the tape and to the data tracks, and, finally, verifies its ability to read the tape's formatting information.

Although the Model TD 440 accepts any DC2000 tapes, the amount of time required to format a tape will lead most users to order preformatted tapes directly from ADIC. Each blank tape requires a low-level format that consumes approximately 48 minutes, and a DOS format that consumes 2 minutes. Once the low-level format has been done, it need not be done again, even if marginal or bad blocks develop. Instead, a verify operation can be performed to map out the bad blocks. This verify operations takes about 25 minutes.

The formatting time is lengthy, in part because the tape is set up as either one 32MB or two 17.8MB DOS volumes; creating DOS format information on a tape is much more complex than preparing a tape for a simple streaming drive. File I/O can be performed just as it is on any DOS volume, using standard COPY, ERASE, and DIR commands available with DOS. The drive is treated just like a hard disk, taking the next (or next two) drive letters when the system is initialized. Programs can even be executed from tape, just as if they resided on a disk drive. Another reason for the unit's lengthy format is that it must generate one error-correction block for every three data blocks.

In addition to working with standard DOS commands, the Model TD 440 also includes special backup and restore programs called SARCHIVE and SRESTORE. SARCHIVE can operate in automatic mode, in which it backs up all subdirectories under the starting directory, or it can prompt to continue after backing up each directory. In addition, the user can create a file that lists specific files or directories to include or exclude when backing up. An option is also available to generate a log file showing each file that was backed up during the session.

Both the SARCHIVE and SRESTORE programs display convenient statistics while performing their operations. They estimate the time of completion before beginning the backup or restore operation and display the elapsed time as they proceed. The number of files and directories, as well as the amount of data backed up or restored (in kilobytes) also are updated constantly. The files that SARCHIVE stores on tape also can be accessed by the standard DOS commands. Therefore, after using SARCHIVE to back up a disk drive, the tape can be examined by using the DIR command (for example, DIR D: if the tape drive is drive D).

The SARCHIVE and SRESTORE programs are menu driven, but they also

can be invoked from the command line for inclusion in a batch file. In addition, the Model TD 440 includes a program called WAITUNTL that enables the backup program to be invoked now for execution at a later time.

The one area in which the Model TD 440 is lacking is speed. Backing up approximately 10MB of data (10,223,616 bytes in 614 files and 25 directories) takes 17 minutes and restoring the same amount of data takes 90 minutes. This is approximately the same performance as the Model 552, and that unit was one of the slowest tested.

Despite the slow performance of the Model TD 440, the sophisticated error detection/correction algorithms used in the unit may convince users who are particularly concerned about data integrity that the extra time is well spent. One out of every three 8,192-byte blocks of data is devoted exclusively to error correction. Therefore, if an error occurs in one block of data, the tape drive can correct it by comparing the error correction block with the other associated data block.

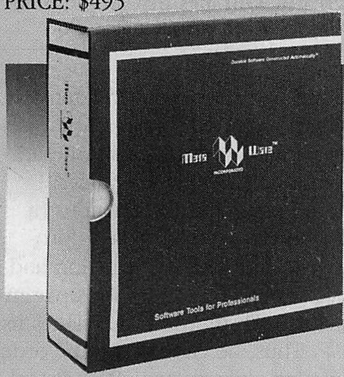
The Model TD 440 offers all of the features of the Model 552 in a much smaller, and more convenient, package, but users must be willing to put up with its lengthy backup sessions.

—STEVEN ARMBRUST

HIGH-C

MetaWare, Inc.
903 Pacific Avenue, Suite 201
Santa Cruz, CA 95060-4429
408/429-6382

PRICE: $495



CIRCLE 350 ON READER SERVICE CARD

MetaWare's High-C stands out in contrast to down-sized and scaled-back C compilers. High-C is even an excellent alternative to the venerable Microsoft C and Lattice C compilers. High-C also has some uniques features that will appeal to software product developers. The basic specifications for High-C are shown in table 1.

The compiler is shipped with seven diskettes. Installation of the compiler is done by a .BAT file that creates the necessary subdirectories and copies the libraries and modules to them. A hard disk is required to use the High-C; with all of the memory models installed, the compiler and libraries occupy 2.6MB. The installation process is clearly explained in the manual. Several demonstration programs can be run to verify that the compiler is functioning properly; sample compilations for all memory models are included.

Along with the compiler and libraries, High-C offers a directory that is full of UNIX-like utilities, including MV (move) and FGREP (a pattern finder). An even more useful addition to High-C is a cross-reference utility that generates a listing of functions and variables that are assigned and referenced within a C program. Unlike many cross-referencers, it can process **include** files and

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multiple modules. To use the cross-referencer, a compilation option must be selected to generate a cross-reference file along with the object.

Table 2 lists the features of the High-C compiler and language. High-C is implemented as a command that generates an .OBJ file which must be linked to produce a final .EXE file. In actual use, the compiler operates in one of two distinct environments, High-C and ANSI standard. The High-C environment is a superset of K&R (Kernighan and Ritchie) C, but with extensions, such as the ability to use underscores in constants, to intermix declarations and statements anywhere in a function, and to use long (up to a line in length) identifiers. These extensions are for improved readability and maintenance of source code. Another convenience is High-C's implementation of frequently used functions, such as **abs()**, **min()**, and **move()**, as intrinsic functions that have been optimized by MetaWare for the target processor.

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TABLE 1: *Specifications*

Version tested	1.3
Supported on other systems	See text
Cross-compiler hosts	See text
Availability of libraries	Yes
Minimum disk space	1.5MB
Minimum RAM	256KB
Supports full language	Yes
Full standard library	Yes
PC-specific functions	Yes
Assembly language interface	Yes
COMPATIBILITY	
MASM	Yes
LINK	Yes
SOURCE CODE	
Start-up sequence	No
Library functions	No
MEMORY MODELS	
Large	Yes
Medium	Yes
Compact	Yes
Small	Yes
.COM	No
OTHER PROGRAMS INCLUDED	
Librarian	No
Assembler	No
Linker	No
Source-level debugger	No
MAKE	No
Other	See text

These specifications can be compared with those for other C compilers in table 1 in "The State of C," (William J. Hunt, January 1986, p. 84). See also table 1 in Marty Franz's Product Watch reviews of Whitesmith's C Compiler (June 1986, p. 201), Let's C (August 1986, p. 177), and MIX C (September 1986, p. 191).

High-C supports all memory models and creates .OBJ files that are linkable by DOS LINK or Phoenix Plink86.

Along with these minor extensions, High-C has included some radical ones, namely parameter associations, nested functions, and full-function values. Using named parameter associations (a concept borrowed from Ada), a programmer is able to call a function and specifically match the function's parameter names with their chosen values using =>. Thus, he can choose the order of a function's parameters. With Pascal-like nested functions, a C programmer can write private functions that share data inside other functions, thereby increasing the ability to hide data in a module. The full-function values allow a programmer to store a nested function's environment and its value in another variable and to reference the entire environment through it.

TABLE 2: *Compiler Functions*

COMPILER OPERATION	
Single-step compile command	Yes
Compile and link	No
Accepts lists of files	No
Accepts wild cards	No
Lists preprocessor output	Yes
Lists assembler output	Yes
Line numbers in error messages	Yes
Header file search list	Yes
Flexible disk file layout	Yes
C LANGUAGE EXTENSIONS	
Embedded assembly language	No
Void function returns	Yes
Enumerated types	Yes
Structure assignment, etc.	Yes
Function argument checking	Yes
LIBRARY EXTENSIONS	
Math functions (sqrt, exp, etc.)	Yes
Unbuffered file I/O	See text
Keyboard input (low-level)	See text
PC screen output (cursor control, cursor attributes, scroll)	See text
Execute programs/DOS (exec/fork and system)	No
DOS services (date, time, etc.)	See text
PC-specific functions	Some
UNIX-compatible functions	Yes
Error recovery (setjmp(), longjmp())	Yes
FILE I/O	
Redirection	Yes
Full path names	Yes
DOS 1.1 support	No
DOS 3.1 file sharing	Yes
Record locking	Yes
ASCII/binary mode	Yes
MEMORY USAGE	
Overlays	Yes
Default stack size	Yes
Stack size settable	No
Stack overflow checking	Yes
8086 FAMILY SUPPORT	
Byte/word alignment	Yes
80186/80286 support	Yes
8087/80287 support	Yes
Automatic sensing	Yes
ROM support	Yes

These features can be compared with other C compilers in table 2 in "The State of C," (William J. Hunt, January 1986, p. 86). See also table 2 in Marty Franz's Product Watch reviews of Whitesmith's C Compiler (June 1986, p. 202), Let's C (August 1986, p. 178), and MIX C (September 1986, p. 192).

High-C is a full-featured compiler that supports both the proposed ANSI C standard and a useful set of extensions.

TABLE 3: *Documentation Quality*

INSTALLATION	
Packing list	Yes
File inventory	Yes
Key files described	Yes
Quick step-by-step procedure	Yes
Instructions for diskette and hard-disk configurations	Yes
List changes from last version	Yes
SET-UP	
Set-up assumptions described	Good
Notes on RAM/second hard disk	Good
OPERATIONS EXPLAINED	
Compile options	Good
Compiler error messages	Good
Linking C programs	Good
Runtime error messages	Good
Runtime options	Good
LANGUAGE / LIBRARY SPECIFICATIONS	
Deviations from Kernighan and Ritchie standard	Good
Data type representation	Good
Memory models and memory layout	Good
DOS and PC-specific features	Poor
ASSEMBLY LANGUAGE INTERFACE	
Segment, group, and class specification	Good
Standard prologue, epilogue	Good
Instruction formats for args, public, extern, struct	Good
Return value conventions	Good
Complete examples	Fair
FILE I/O	
Redirection	Good
Console I/O	Good
Device I/O	Good
Buffered versus unbuffered	Poor
ASCII versus binary modes	Good
LIBRARY DOCUMENTATION	
Average lines per function	20
Cross-reference information	Fair
Functions in table of contents	Good
Examples of use	Fair
MANUAL ORGANIZATION	
Detailed table of contents	Good
Index with functional entries	Fair
Order of function documentation	Alpha.
OVERALL RATING	Good

These notes on documentation can be compared with those for other C compilers listed in table 3 in "The State of C," (William J. Hunt, January 1986, p. 88). See also table 3 in Marty Franz's Product Watch reviews of Whitesmith's C Compiler (June 1986, p. 203), Let's C (August 1986, p. 179), and MIX C (September 1986, p. 192).

Overall, the High-C documentation was complete and informative, but a more conventional index would be welcome.

The High-C extensions give the product a Pascal flavor. Because many of the extensions are in areas where the K&R standard is vague or nonexistent, they cause little problem when porting normal C programs to the High-C compiler. Some common extensions of version 7 UNIX C (such as void functions and enumerated types) have been included. These changes make High-C a stronger language for large projects with multiple programmers; they increase the ability of the knowledgeable C programmer to structure code.

In addition to this enhanced version of the C language, High-C also compiles programs conforming to the proposed ANSI (X3J11) standard and disallows the High-C extensions. This is done by using a switch at compilation time. Other switches to the High-C compiler select the memory model, object file name, and cross reference and list file generation options. An after-

market MAKE utility (such as PolyMake from Polytron) is a necessity because High-C supports neither wild cards nor multiple file names on the command line. The compiler's default option settings can be configured through a separate command that stores common defaults in the compiler's .EXE file and makes them permanent.

A key addition to the C language as implemented by High-C is the **pragma** statement. Another concept borrowed from Ada, this is a directive to the compiler in the source file that specifies listing format, code generation, array checking, external labels, and register variable usage—in short, anything that concerns the generation of the final module. A set of **pragmas** is placed in a source file, profile, included in the module when it is compiled. Different profiles are used for different environments: one with stack and array checking enabled for module testing and one with checking disabled for maximum-performance production programs.

High-C supports five memory models for the PC: small (64KB code, 64KB data), compact (64KB code, large data), medium (large code, 64KB data), big (multiple 64KB code segments, large data) and large (large data, large code). They are selected by a compilation switch or a **pragma** statement. Overlays can be generated for the Phoenix Plink linker. The compiler generates code for the 8087/80287 numeric coprocessor and/or the 80186/80286 processors with **pragma** statements. These features allow the exact control of code generation for production applications.

High-C supports the UNIX standard library (see table 3) and the usual extensions, such as **alloc()** and **setjmp()**. An unusual feature of this compiler is that more primitive I/O functions, such as **read()** and **open()**, are handled with a utility package that must be defined through an **include** file and not directly through library functions as they are in most C compilers. This allows users writing embedded applications (those that do not use DOS, such as programs placed in a ROM) to isolate and write their own implementations of these nonportable functions.

High-C also has a flexible system for interfacing to other languages and libraries. The **pragma** statement can be used to tell the compiler which interface an external module has, including call by value (C standard), call by reference, and called function pops arguments. This feature should allow High-C to interface with most aftermarket C libraries. The manual states that by using the external interface **pragmas**, High-C can call Professional Pascal and assembly language modules, and it provides examples for doing so.

High-C is weak in its PC-specific library functions. Only the most basic level of access, interrupt calls and basic file I/O, is supported. Higher-level graphics or directory functions must be written by the user or accessed through an aftermarket library.

The documentation for High-C is summarized in table 3. The High-C manual's loose-leaf binder contains far more pages than it can hold successfully. The documentation is divided into an installation guide, a programmer's reference section, a library reference, and a language reference.

Content is complete, but very technical in the best (or worst) UNIX tradition. Its strong points are the installation guide and language description, which are particularly accurate. The library reference and interfacing sections are its weak points. Sample programs and some library source code is included and is well commented.

Benchmark results are given in table 4. As the benchmarks show, compi-

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TABLE 4: *Benchmarks*

COMPILE TIMES	
60-line file	58.6
150-line file	79.0
500-line file	64.2
LINK TIMES	
1 object file	53.4
6 object files	59.5
PROGRAM SIZES (bytes)	
Eratosthenes sieve	24,176
Pentathlon	26,016
GENERAL OPERATIONS (small/large model)	
Function calls (Fibonacci)	21.8/ 28.2
Integer arithmetic	30.3/ 30.3
Long arithmetic	98.5/100.5
Subscripts (character count)	22.3/ 24.9
Pointer use (string copy)	36.4/ 42.9
With register variables	32.9/ 43.0
Eratosthenes sieve	20.7/ 20.7
With register variables	18.2/ 18.8
FILE I/O (small/large model)	
Read/write	
Diskette to diskette	6.5/ 6.3
Hard disk to hard disk	3.1/ 3.0
Getc/putc	
Diskette to diskette	3.5/ 3.4
Hard disk to hard disk	4.3/ 4.3
FLOATING POINT OPERATIONS (small/large model)	
Add/multiply (dot product)	49.2/ 62.8
Exp/log	65.0/ 77.6
Sin/tan (trig functions)	62.5/ 75.4

All times are in seconds.

Benchmarks were run on an IBM PC/XT with 640KB, 20MB hard disk, DOS 2.1, and no 8087 numeric coprocessor. These features can be compared with those for other C compilers in table 4 in "The State of C," (William J. Hunt, January 1986, p. 90). See also table 4 in Marty Franz's Product Watch reviews of Whitesmith's C Compiler (June 1986, p. 205), Let's C (August 1986, p. 179), and MIX C (September 1986, p. 193).

Although it is a bit slow in compilation, High-C is among the fastest of the C compilers in the speed of the compiled programs that it produces.

lation times are slower than average—probably because the compiler performs a great deal of optimization on the program prior to generating code.

Once the compiler finishes, however, the object code it produces is faster than the compilers reviewed in "The State of C" (William J. Hunt, January 1986, p. 82). The .EXE files were larger than average, but their size had not been reduced by **pragma** statements (a size/speed compilation option is available) or by linking with smaller versions of the library without floating-point formatted output in them.

Only one problem marred an otherwise excellent benchmark performance by High-C; when compiling the AUTO6.C source file, the compiler's optimizer removed several statements containing a variable that was assigned but never referenced within the module. Later, the code generator generated a system error trying to generate code for the removed statements. Inserting a dummy reference to the offending variable solved the problem.

A final feature of High-C is the MetaWare arrangement with Plum Hall to provide training seminars to High-C users at a reduced price. This further demonstrates MetaWare's commitment to supporting technical users.

MetaWare's High-C is a powerful, full-featured C compiler well worth consideration by users who undertake large development projects.

—MARTY FRANZ

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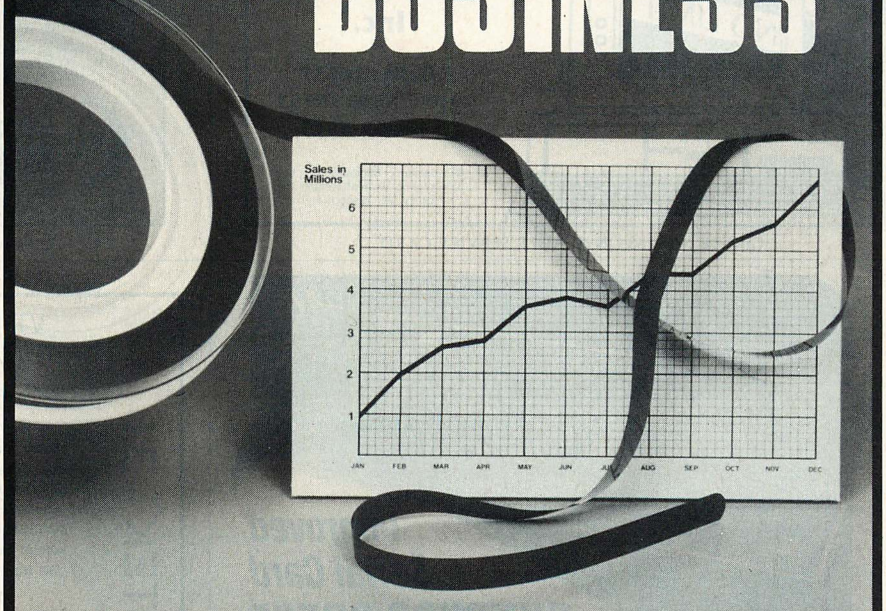

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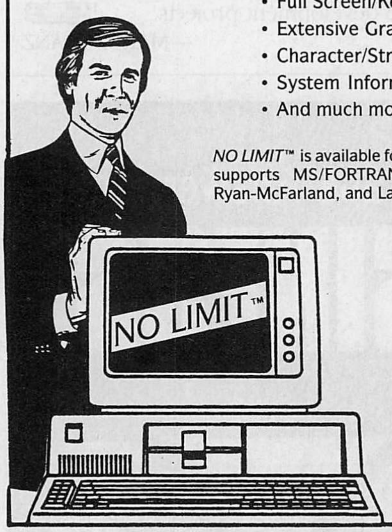

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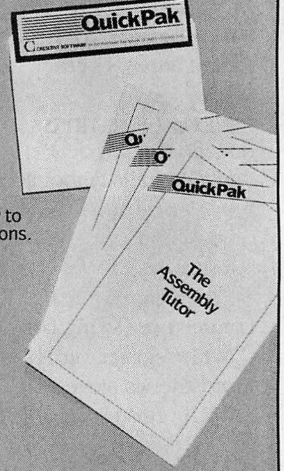

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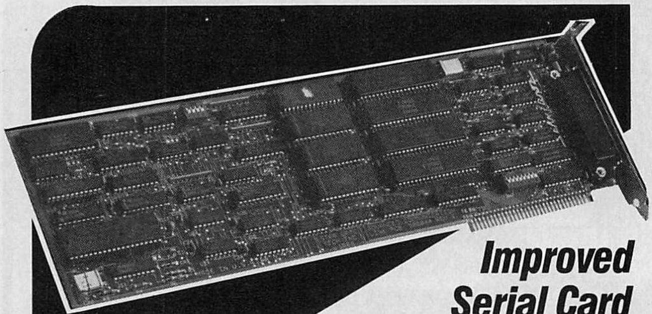

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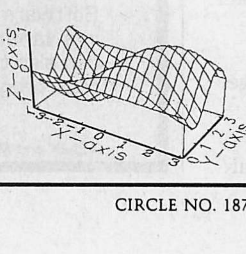

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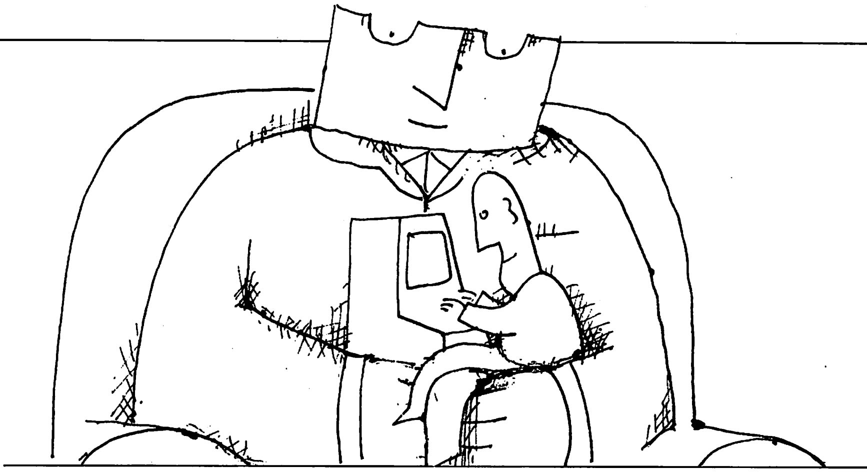
Three Misconceptions

Although they may be unspoken or subconsicous, some deeply rooted misconceptions affect the way software designers think about human factors.



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When the topic human factors is mentioned, some mental response comes to mind. Consider this list:

1. Easy-to-read messages
2. Good on-line help
3. Icon and windows
4. Using a mouse
5. Simplicity

Item 1 is the response for many people. Certainly, readable messages are a part of human engineering. But are they a large part? No. This is precisely what is wrong with item 1 as a response. To think about human factors in this way is a rather deeply rooted misconception.

Ah, you say, do not be foolish. No one would give the definition: "Human factors is the study of writing clear messages." I agree. But the point is our misconceptions are more subtle. They affect our attitude, our work. People who relate to item number 1 are likely to think of human factors as window dressing, an add-on to development; on the other hand, they will probably not articulate this view.

This is probably a consequence of being in a field that is considered "motherhood and apple pie." No one is against human factors or supports poor human factors. Accordingly, we in the field have a different task. It is not to convince people of the importance of human factors, but to define what human factors are and uncover some of the many unspoken and deeply rooted misconceptions. You can say that "many believe, but few go to church."

Here is my list of misconceptions.

- The primary goal is to help novices.
- Users will feel comfortable with subsets.
- Human engineering is not particularly a technical matter.

I believe that there are many users, engineers, and designers who (privately, perhaps subconsciously) hold such views. The misconceptions are largely unspoken; they reflect a set of established attitudes.

The primary goal is to help novices. When designing systems, designers often ask how Charlie, the novice, would cope with it. When they document the system, try to write manuals, provide on-line help, or introduce special keys, the novice is kept in mind.

A consequence of this attitude is that, subconsciously, we think of human factors as babying the user. As an aside, notice a looming contradiction—the system evolves toward greater complexity, yet we add even more complexity (on-line help, special features) to help the novice. Moreover, the real workhorse systems, which are not particularly meant for novices, can have the worst human factors.

The marketplace is alive with many different computer systems: electronic mail networks, word processors, application packages, and implementations of computer languages. The people who use these systems are not primarily novices. When a new system is introduced, those who encounter it are certainly first-time users of that new system, but most of them have probably had experience with other systems and similar pieces of software. Therefore, they will be transferring their skills from a previous experience to a new one; in other words, they can be called *transfer users* (see Good et. al., "Building a User-Derived Interface," *Communications of the ACM*, October 1984).

Charlie the transfer user would undoubtedly be able to apply his knowledge of his own word processing system to a new one. His concerns as a transfer user would be substantially different from those of Charlie the novice. Transfer users are familiar with automation, command languages, and screen layouts. They know many of the small details that are needed in using a system: how to use special keys, invoke a command, or save work. Table 1 outlines the differences between the novice and the transfer user.

Even the true novice may not remain a novice very long. Often, people are taken with the novelty and challenge. They become "experts" in a short period of time, even when complexity interferes with useful work.

The point is that spreadsheet or compiler, novice or expert, the human factors in day-to-day usage are the issues that really count.

Users will be comfortable with subsets. The popular wisdom is that small systems are desirable. Nonetheless, systems have a tendency to grow. When a system design begins to snowball, by its own momentum the subset idea becomes increasingly attractive. The subset idea is simple—users will pick and choose

TABLE 1: *Differences between Users*

THE NOVICE	THE TRANSFER USER
Is unsure of automation	Knows what automation is
Needs encouragement	Wants to get work done
Develops skill slowly	Becomes skilled rapidly
Needs gentle documentation	Needs a good reference manual
Is hesitant with new combinations	Thrives on technical consistency

One misconception is that products must be designed for novices. Most users are transfer users. Even novices become experts in a short time.

their own features, eventually establish a reasonable selection, and then will be comfortable with it. So what is wrong with large systems anyway?

Many arguments are lodged against large scale in computer systems. Some of them have to do with cost. Others have to do with documentation and the difficulty of implementing large systems. Users should question every feature in a system. They may not need so many options if the system does the simple tasks it is designed to do, and does them well. Nevertheless, what is really wrong with the subset idea from the user's point of view?

Using a system well requires documentation. A system that is larger than required forces the user to face a document describing many features that are irrelevant to the problem at hand. As I noted in my first article in this column (see "Computer Attitudes," November 1986, p. 193), Charlie had no use for a magic debugging tool when he was learning his new word processing system. Irrelevant information intimidated him. He might well have muttered: "Oh, Lord! Thy system is so big, and Thy user, so small."

Moreover, the larger the system the more likely that the documentation will be inadequate. Manuals tend to be pieced together under increasing pressure. The examples become sterile; the text uninteresting. The documentation can deteriorate into nothing more than the reports of one engineer to another. The result is a general loss of quality.

No designer can predict which part of a system a user will be using. Any system responses, help frames, or menus can only force upon the user information about unknown topics. Some operations, such as program configurations or file options, may be barely understood. The user may get lost taking an unknown option and wind up in a dead end, not knowing whether to recover or begin again. When the user is on the right track, the system is less likely to give the kinds of specific information that the user really needs.

Users feel most comfortable when they understand everything they see: the menus, the icons, the commands, the options, and the messages. They find themselves at ease when they believe they are in complete control. It is similar to feeling comfortable driving your own car rather than somebody else's. When the driver understands all the controls and is able to use them confidently, driving is safer, easier, and certainly less stressful. That is why Charlie eschewed templates pasted on his keyboard—he wanted his fingers to move around the keys without having to think about it.

The substantive question here is: Why can't users simply find their own subsets and function there conveniently? In response, I need to ask more questions: Whose subset? How do I get the document for the subset that I use? How can I disregard instructions on the screen that are of no relevance? What about my specific needs? Can I grow with the system or must I grope with it? Can I be sure that the subset I am using is the optimum one? Am I ignorant of more efficient ways to do what I am currently doing?

If I am not comfortable with a subset, I will want to learn more until I am satisfied that I understand the system as well as I can. If I cannot do this, if I finally give up exploring, I will reluctantly hold on to my subset but with a feeling of misgiving. Is this what human engineering is all about?

If this is so, the system will always seem to be bigger than I am, and my subset is just a myth.

Human engineering is not particularly a technical matter. Few human factors specialists would agree with this statement, but my guess is that some system developers secretly believe it. Some liken human factors to making system messages more pleasing for the user to read.

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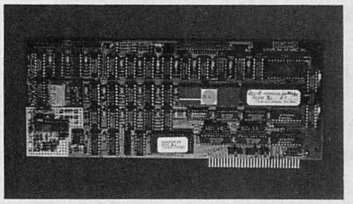

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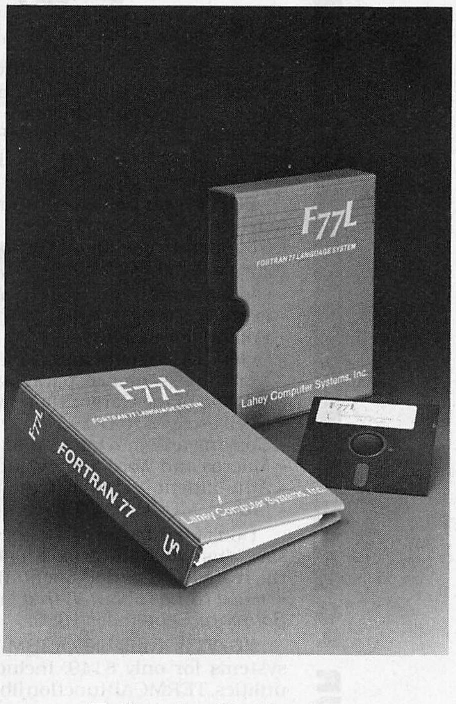

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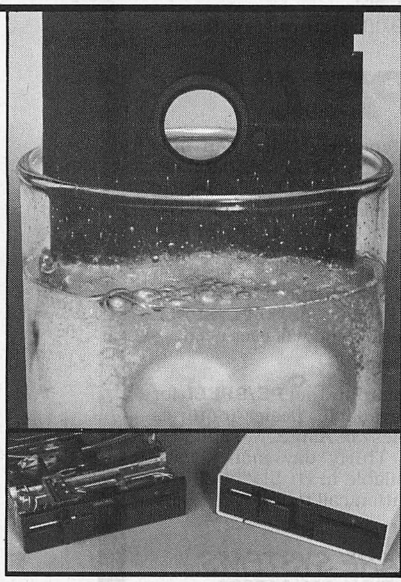

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If human factors are important, they should be a concern from the beginning to the end of the software life cycle. Even when the requirements for a proposed system are being sketched, human factors arise quickly. Questioning the need for features, scaling down the requirements, and looking for clean technical solutions that will meet the needs of the user—these have implications for human factors.

In developing a good technical design, the designer should consider such questions as: Are so many special-purpose keys really necessary? How should commands or menus be organized? How should screen management work? What notations should be used?

When the design is started, conflicting principles may have to be resolved. Perhaps some experiments may need to be run in order to test competing ideas. Data can be gathered on an existing system to see which features are the most confusing. If an on-line help system cannot be developed in a reasonable manner, perhaps the matter should be dropped and other avenues of user training explored. For example, cursor movement, file management, and command language principles must be discussed and implemented as an integral part of human factors.

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Consider these questions:

- What is a good syntax model?
- Do options have consistent syntax?
- Which are commands versus subcommands?
- Which features can be arranged into sensible groups?
- Should commands be combined?
- Should all options have a default?
- Can features be grouped under a single option?

These are technical issues that directly affect the user, ease of learning, recall, and documentation.

Human engineering is not something that can be grafted on to an existing system. It is the fiber of technical development.

Henry F. Ledgard is a private consultant, specializing in software engineering, audits, and education as well as human factors. He holds a Ph.D. from MIT.

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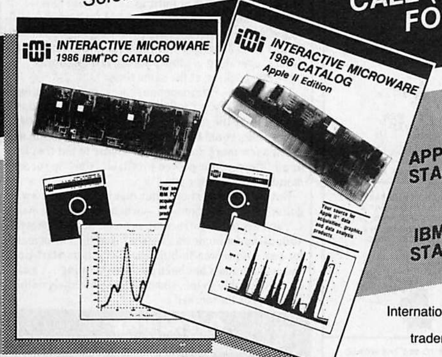

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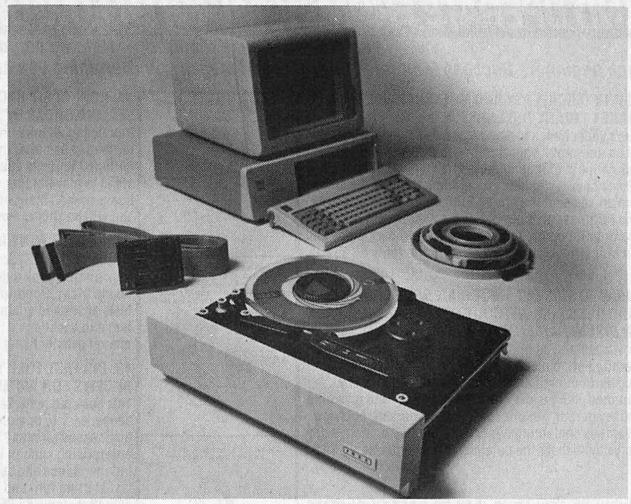

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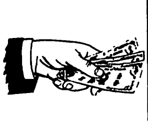

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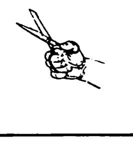

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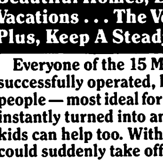

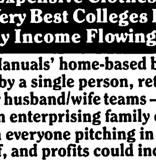

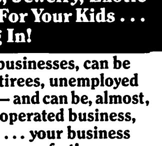

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Micro Database Management: Practical Techniques for Application Development
Robert H. Bonczek, Clyde W. Holsapple, and Andrew B. Whinston (Academic Press, Inc., Orlando, FL, 1984)
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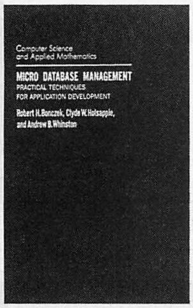

The abstract discussions and simple examples included in books on database management often fail to give readers the in-depth understanding of practical techniques that is necessary for application development. The authors of *Micro Database Management*, however, have selected for their book an interesting assortment of challenging real-world application problems. Each of these problems is addressed with a specific database management system (DBMS) to illustrate practical development techniques. Micro Data Base Systems III (MDBS III) is used as the DBMS of choice for the examples included throughout the book.

The book is written on a professional level, but the carefully selected examples help the reader's understanding of the basic and complex concepts involved. Professional developers and students will find *Micro Database Management* useful. It covers all the usual DBMS fundamentals: data items, record types, and relationships between record types, as well as many advanced topics that usually are not discussed in depth in books on the subject, such as the relatively new postrelational (or extended-network) data model, end-user interface, database restructuring, and database integrity and security.

The first three chapters provide a general background in the area of applications development for microcomputers. The evolution of database management is studied, and file management systems are contrasted with DBMS. Six end-user needs are defined that must be satisfied by the database management system as inexpensively as possible: ability to manipulate data without programming or knowledge of data structures; data security; compatibility with existing hardware and software; portability to other environments; high performance; and extendability. The authors indicate that high-quality micro application software can be built to match the software available on mainframes, provided the appropriate tools are used. Characteristics and features of such tools for data-handling, screen-handling, and control-computation tasks are discussed in detail.

Micro Database Management provides an excellent insight into the fundamentals of logical structuring. A very practical technique for designing schemas is presented that systematically takes the developer through the seven steps necessary for a complete design: identify each data item and its purpose; collect items for which there is a one-to-one relationship into record types; put each remaining data item into a record type; identify one-to-many relationships between record types; delete duplicate relationships; create many-to-many relationships for all other record types; and create additional relationships using artificial record types to support required reports.

The book also covers database processing. Various data manipulation commands are discussed in detail. The chapters on this subject provide in-depth illustrations of how an actual application system is developed. These examples, like the many others included in the book, play an essential role in clarifying sophisticated concepts.

The database management systems used in the examples are designed using MDBS III data manipulation language (DML). Although this DML can be used with a number of host languages, the examples in the book are not written in any specific high-level language. Instead, a pseudolanguage is used to make the material accessible to all readers. The syntax of this language is explained in the book and proves to be very easy to understand.

One of the book's chapters is devoted to a discussion of the interactive data manipulation language (IDML), a low-level procedural language, and the query retrieval system (QRS), a high-level non-procedural language. A second chapter shows how some of the advanced features exclusive to the post-relational data model—such as direct representation of many-to-many, recursive, and forked relationships—can help simplify the task of the applications developer. The book offers performance enhancement guidelines for advanced developers. It illustrates how a performance-conscious developer can take advantage of the underlying physical structure to optimize performance.

Another chapter gives a complete, detailed case study, which does a good job of encompassing all the concepts covered in previous chapters and provides an excellent illustration of how an actual problem can be implemented. While multiuser database processing is often ignored in database books, *Micro Database Management* has detailed examples (using MDBS III facilities) of how to develop effective multiuser applications software.

Although many concepts discussed in the book would be useful in any DBMS context, the book's full potential is realized only when it is used in conjunction with MDBS III. The book is an important contribution to the database field. It can provide practical knowledge for applications development and should be a valuable addition to any database library.

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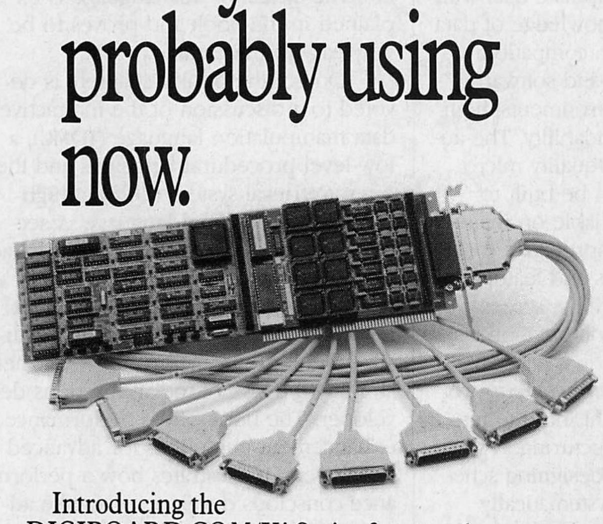

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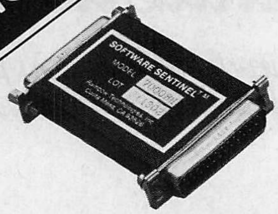

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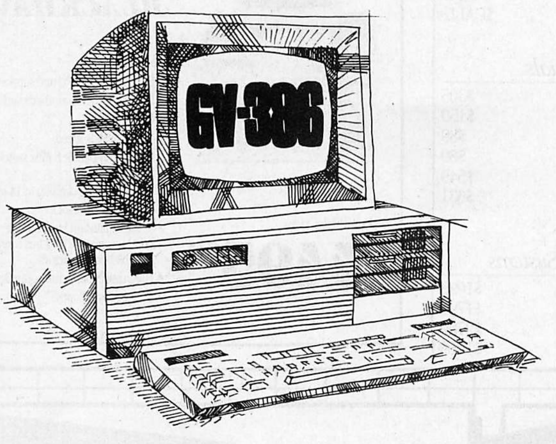

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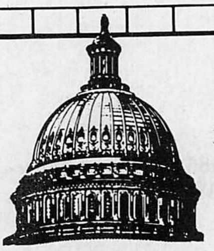

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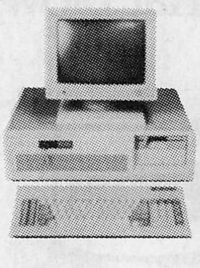

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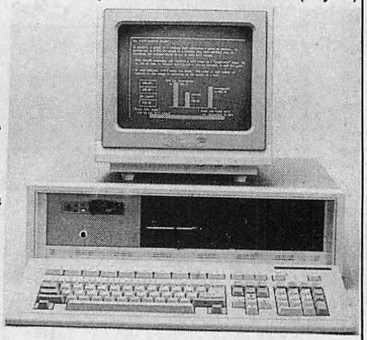

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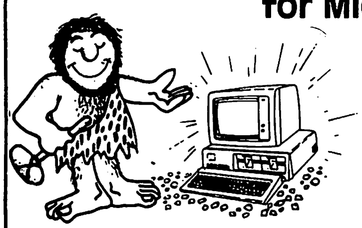

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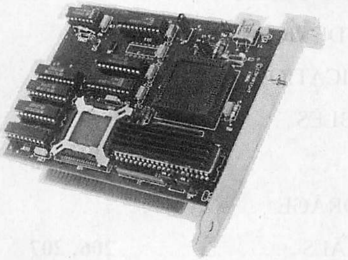

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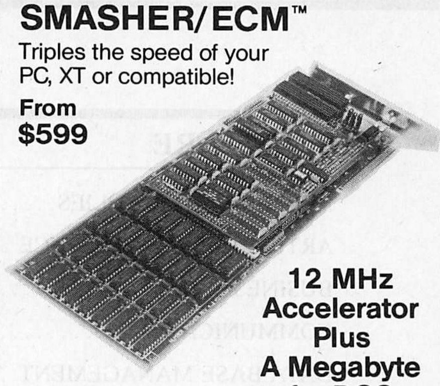

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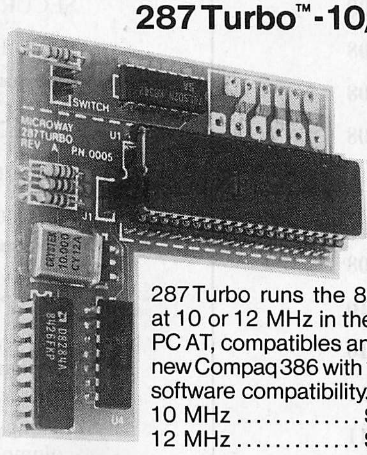

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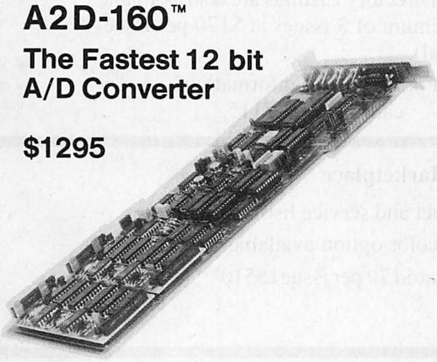

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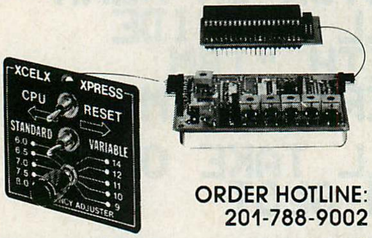

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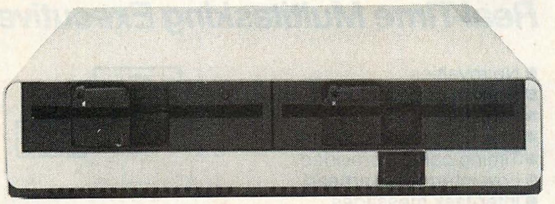

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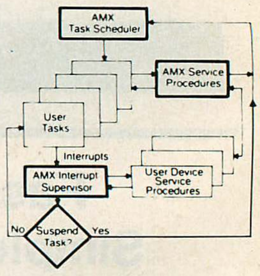

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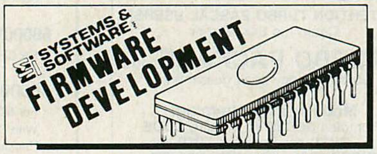

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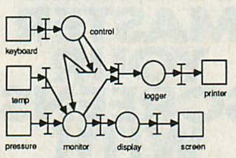

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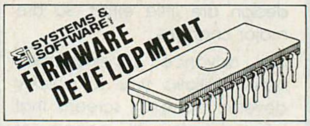

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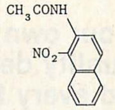

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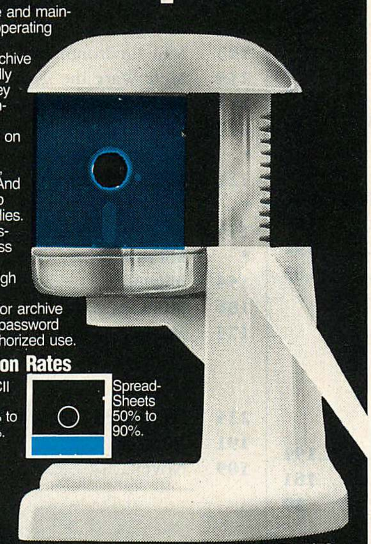

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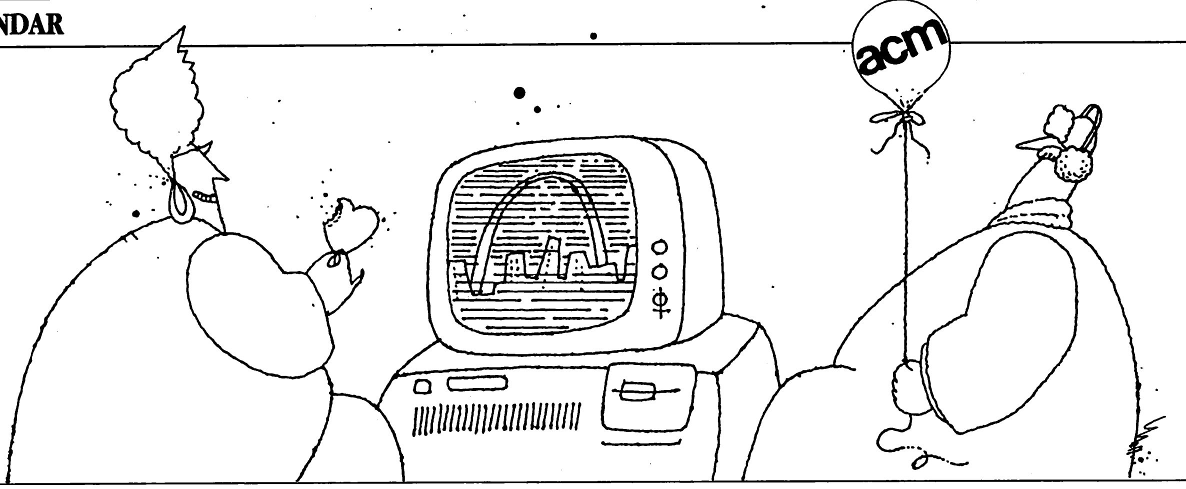

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FEBRUARY

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Third International Conference on Data Engineering
Los Angeles, CA
Sponsor: IEEE-CS
Contact: IEEE-CS, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903; 202/371-0101

February 10-12
Systems Design and Integration Conference
San Francisco, CA
Sponsors: IEEE and ERA (Electronic Representatives Association)
Contact: Deanna Myerson, Electronic Conventions Management, 8100 Airport Blvd., Los Angeles, CA 90045; 800/421-6816; in California, 800/262-4208

February 10-13
Designing Modern Software/User Interfaces
Anaheim, CA
Sponsor: Integrated Computer Systems
Contact: Yolande Amundson, Manager Education Services, 5800 Hannum Avenue, P.O. Box 3614, Culver City, CA 90231; 800/421-8166; in Canada, 800/267-7014

February 12-13
Implementing DB2
Chicago, IL
Sponsor: Digital Consulting Associates, Inc.
Contact: Seminar Services Department, 8 Windsor Street, Andover, MA 01810; 617/470-3880

February 17-19
Computer Science Conference '87
St. Louis, MO
Sponsor: ACM
Contact: Arlan DeKock, Conference Chairman, University of Missouri-Rolla, Rolla, MO 65401; 314/341-4491

February 22-28
Third Artificial Intelligence Applications Conference
Kissimee, FL
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Contact: Jan Aiken, Aion Corporation, 101 University, Fourth Floor, Palo Alto, CA 94301; 415/328-9595

February 23-24
Micro-mainframe Links
Boston, MA
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IBM's DBMS and 4GL: Strategies and Implementation Alternatives
Toronto, Ontario, Canada
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Contact: Seminar Services Department, 8 Windsor Street, Andover, MA 01810; 617/470-3880

MARCH

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GUIDE 67
Anaheim, CA
Sponsor: GUIDE
Contact: Bill Reinberger, GUIDE International Corporation, 111 E. Wacker Drive, Chicago, IL 60601; 312/644-6610

March 17-19
Reliability in Distributed Software and Database Systems
Williamsburg, VA
Sponsor: IEEE-CS
Contact: Edwin C. Foudriat, NASA, Langley Research Center, Information Systems Division, MS 469, Hampton, VA 23665; 804/865-3535

March 22-26
Computer Graphics '87
Philadelphia, PA
Sponsor: National Computer Graphics Association
Contact: NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031; 800/225-6422; in Virginia, 703/698-9600

March 23-27
Theory and Practice of Software Development
Pisa, Italy
Sponsor: Universitè di Pisa
Contact: Pierpaolo Degano, Dipartimento di Informatica, Universitè di Pisa, Corso Italia, 40 I-56100 Pisa, Italy

March 30-April 2
Ninth International Conference on Software Engineering
Monterey, CA
Sponsors: ACM SIGSOFT and IEEE-CS
Contact: William E. Riddle, Software Design and Analysis, 1760 Bear Mountain Drive, Boulder, CO 80303; 303/499-4782

March 31-April 3
ANSYS 1987 Conference
Newport Beach, CA
Sponsor: Swanson Analysis Systems, Inc.
Contact: Swanson Analysis Systems, Inc., Johnson Road, P.O. Box 65, Houston, PA 15342-0065; 412/746-3304

March 31-April 3
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Boston, MA
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Contact: Yolande Amundson, 5800 Hannum Avenue, P.O. Box 3614, Culver City, CA 90231; 800/421-8166; in Canada, 800/267-7014

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Deadline: February 1
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Zurich, Switzerland
(May 5-8, 1987)
Sponsor: IFIP WG
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Deadline: February 16
Operating Systems Principles
Austin, TX
(November 9-11, 1987)
Sponsor: ACM
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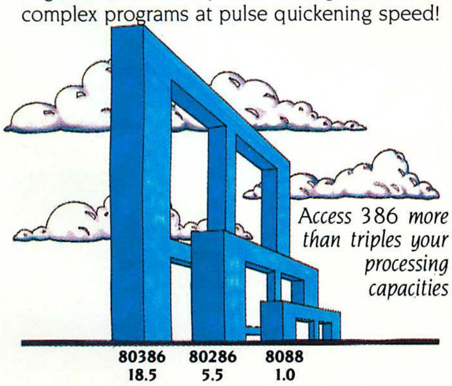

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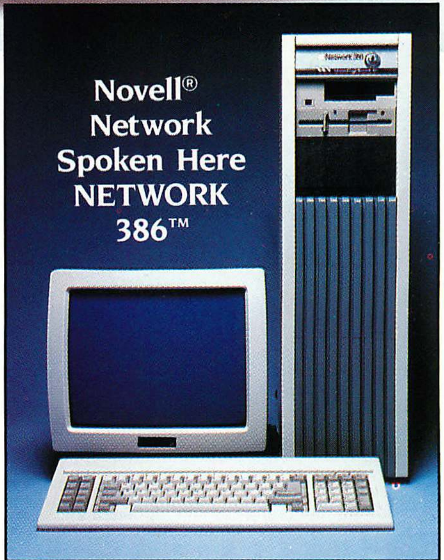

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